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A comparison of achievement resulting from learning electronics concepts by computer simulation versus traditional laboratory instruction

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A comparison of achievement resulting from learning electronics concepts by computer simulation versus traditional laboratory instruction

by

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DEDICATION

I dedicate this study to everyone who lost their precious lives in the eight year war between Iran and Iraq. They were the champions who fought so people like me could continue to study and do research for the benefit of the next generation. I further dedicate this study to all Americans who lost their precious lives in World War II and the Vietnam conflict.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

This study was designed to compare student achievement resulting from learning electronics concepts by computer simulation versus traditional laboratory instruction (manipulating actual components). The purpose of this study was to enhance the student knowledge about passive-devices electronics circuitry. Two groups of college students participated in this study over an academic year.

The review of literature indicated three types of results from the computer simulation and its effects on students: 1) positive effect 2) negative effect 3) no effect. The majority of researches indicated that computer simulation enhances the student knowledge of the subject matter.

Pretests were given to both groups in the first two weeks of this study. Twelve topics were covered in duration of this study. Each group received one hour of lecture and four hours of laboratory instruction per topic. The experimental group received two hours of computer simulation laboratory instructions followed by two hours of traditional laboratory instructions. The control groups received four hours of traditional laboratory instructions. Twelve quizzes, twelve homework assignments, a midterm and a final examination were given to the participants. All quizzes , homework assignments in addition to the midterm and final examinations were based on multiple-choice questions.

Findings indicated that there were no significant differences between the control group and the experimental group for homework assignments, midterm and final, however, there were significant differences for the quizzes at α-.05. The control group scored significantly for the first (Ohm's law and power), fifth (alternating current and voltages), sixth (capacitors) and eleventh (frequency response of RLC circuits) quizzes. Interactions between the students were detected for the homework variable. Interactions between the midterm and the final examination were also detected.

The results of this study revealed that the computer simulation should be applied to complex topics, however, this learning process should began with the beginning courses. This study also concluded that more time is needed for students who do not have computer literacy. Overall findings were in favor of using computer simulation in industrial/electronics technology and its related areas.

CHAPTER I. INTRODUCTION

Computer technology experienced a major breakthrough in the 1980s with the help of microprocessors developed by large corporations such as Intel and Motorola. This improvement in electronics and computer technology has allowed programmers to make what was unreachable twenty years ago on most mainframe computers, to become as simple as child's play. Today, programming can be done on a variety of microcomputers at home. During the past thirty years, especially within the last ten years, the United States has witnessed the integration of computer technology in virtually every sector of society.

In recent years, large numbers of computers have infiltrated the educational system and they have been crucial for meeting many instructional needs (Milner & Wildberger, 1974). As result of this infiltration, it has become necessary to evaluate how effective computer simulation is as an instructional method or strategy. Much research has been focused on the effect of computer simulation in many areas (Baureis, McKinley, Seitzer, 1991; Konstadakellis, Siskos, Laopoulos, 1992; Wen & Triplett, 1991). However, in relationship to education, there is no consensus as to whether computer simulation should be implemented into the classroom (Banzhaf, 1991). Perhaps because of this uncertainty about the usage of computer simulation, especially in entry level courses, more specialized studies should be conducted (Nejad, 1992).

There is evidence that many industries are using computer simulation. Large corporations such as IBM, Apple and DEC have already experienced the advantage of design with computer simulation. Many companies have adopted the simulation procedure (Banzhaf, 1991). The complexity of electronics circuitry has made computer simulation a necessity in modern electronics industries. In fact, several universities such as Massachusetts Institute of Technology, University of California at Berkeley and Iowa State University are using computer simulation as a tool for designing electronic circuitry.

Despite the fact that studies have been conducted on computer simulation, the effectiveness of it varies from population to population and study to study (Euckert, 1984; Taylor, 1984); therefore, more studies with specific populations are needed. This research study compared the traditional laboratory teaching method (using actual components) with the use of computer simulation in conjunction with the traditional laboratory teaching method. One group received laboratory instruction in the traditional method which involved working with the actual components. The second group received laboratory instruction in the traditional method along with computer simulation. In this study the independent variable was the method of instruction whether it was traditional, hands on, or a combination of traditional and simulation. The dependent variable in this study included a set of homework assignments and a set of quizzes for each topic covered plus midterm and final tests.

The central purpose of this study was to determine if computer simulation should be applied in classes covering beginning level course of electronics to enhance higher student achievement scores and mastery of skills.

Statement of the Problem

This study was designed to evaluate and compare the effectiveness of computer simulation techniques in teaching basic electronic circuitry versus the traditional method involving passive components (resistors, capacitors, inductors, etc.) to freshmen college students.

Objectives of the Study

The objectives of this study were to:

1. Compare the level of achievement between a group of college students who learned basic electronics circuitry (passive components) using laboratory experiments and a second group of college students who learned the same concepts using laboratory experiments and computer simulation.
2. Determine the effectiveness of using computer simulation as opposed to using traditional laboratory experiments employing passive electronics circuitry.
3. Assess the instructional methods and their effectiveness in teaching passive electronics circuitry.

4. Evaluate the effectiveness of each instructional method by analyzing the results of posttests given at the end of each topic.
5. Assess the effectiveness of each instructional method by analyzing the results of the tests given at the middle and at end of each topic covered in this course.
6. Evaluate the effectiveness of instructional methods by analyzing the results of difficult items in all posttests.

Research Questions

This study was conducted to answer the following questions:

1. Is there a significant difference between the two instructional groups as measured by the means of pretest $PRE_{Cnt.}$ and $PRE_{EXP.}$(pretest)?
2. Is there a significant difference between the two instructional groups as measured by the means of posttest Q_1 through posttest Q_{12} (quizzes)?
3. Is there a significant difference between the two instructional groups as reflected by the means of posttest H_1 through posttest H_{12} (homework)?
4. Is there a significant difference between the two instructional groups as measured by the means of posttest MID (midterm)?
5. Is there a significant difference between the two instructional groups as measured by the posttest FIN (final)?
6. Is there a significant difference between the means of the two instructional groups on the difficult items of all posttests?

7. Is there a significant difference between the attendance of the control group and the experimental groups?

Assumptions of the Study

This study was based on the following assumptions:

1. The students were normally distributed between the control group and the experimental group. Complete, intact classes participated in this research.
2. The computer awareness of the control group and the experimental group were equivalent.
3. The electronics background of the control group and the experimental group were also equivalent.
4. The instructor was not biased toward either the control group or the experimental group in instruction or assessment.
5. The control group and the experimental group did not interact to a degree which biased the findings significantly.
6. All the laboratory experiments were the same for both the control and the experimental groups.

Delimitations of the Study

The students participating in this study were enrolled in the spring and fall semester of 1992 in IEDT 140 (basic electronics) in the Department of

Industrial Education and Technology at Iowa State University. This study was limited to the topics listed below during the thirty weeks of experiment[1]:

1. Ohm's law and power
2. Series circuits
3. Parallel circuits
4. Series-parallel (combination) circuits
5. Alternating current and voltages
6. Capacitors
7. Inductors
8. Transformers
9. Frequency Response of *RC* circuits
10. Frequency Response of *RL* circuits
11. Frequency Response of *RLC* circuits
12. Pulse response of *RC* and *RL* circuits

Procedures of the Study

The following procedures were used in the study:

1. Identify and isolate the problems.
2. Conduct a related review of literature.
3. Identify the population.

[1] The sequence and the amount time spent was the same for both control and experimental groups.

4. Select and formulate the pretests and posttests.
5. Administer the pretest.
6. Teach the topics.
7. Administrate the posttests.
8. Collect data.
9. Implement the statistical analysis.
10. Analyze the results of pretests and posttests.
11. Identify the findings.
12. Interpret and discuss the proper conclusions and recommendations and prepare the final report.

Definition of Terms

Active Components - Electronic devises that require biasing for operation.

Breadboarding - The process of installing components on the a circuit board and connecting them to a specific circuit (Floyd, 1991).

Computer Assisted Learning (CAL) - Using a computer to aid in the *learning* improvement process.

Computer Simulation - Using a computer to duplicate an almost identical circumstance and finding the consequences of that circumstance.

Computer Assisted Instruction (CAI) - Using a computer to aid in the *teaching* improvement process.

Design Center - A graphical interface software developed by MicroSim Corporation to use Windows[2] to draw electronics circuitry.

Environmental Protection Agency (EPA) - An agency of the United States Government that sets, monitors and enforces laws and regulations in both industrial and civilian sectors to ensure air and water quality.

Experimental treatment - A combination using the traditional method and computer simulated laboratory instruction.

Passive Components - Electronic devices that do not require biasing to operate, such as resistors, capacitors and inductors.

Probe - A graphical interface that allows the user to view the wave-form on a computer monitor.

PSpice[3] - A software program developed and registered by MicroSim Corporation to design and analyze analog and digital circuitry.

RC circuits - A circuit consisting of at least one resistor and one capacitor connected either in series or parallel.

RL circuits - A circuit consisting of at least one resistor and one inductor connected either in series or parallel.

RLC circuits - A circuit consisting of at least one resistor, one inductor and one capacitor connected either in series or parallel.

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[2] Windows is the trade mark registered by Microsoft Corporation.

[3] PSpice is the trade mark registered by MicroSim Corporation.

SPICE - *S*imulation *P*rogram with *I*ntegrated *C*ircuit *E*mphasis.

Traditional laboratory - Employs hands-on experiments with usage of actual components.

CHAPTER II. REVIEW OF LITERATURE

There has been a large number of studies related to computer simulation. It is essential, however, to emphasize, the studies which have been done in recent years. Evidence suggests that the results of these studies would give more significance by comparison to earlier studies. Recent studies are of great value due to the improvement of hardware and software design, and availability and affordability of microcomputers. In educational systems three types of results have been reported relating to implementation of computer simulation:

1. Improvements in better understanding of the topic(s) resulting in higher performance (positive results).
2. Decline in better understanding of the topics(s) resulting in lower performance (negative results).
3. No significant changes in better understanding of the topics(s) resulting in identical performance (same results).

Regardless of the type of software used in the following studies, these categories exist, however, since this research involves usage of a microcomputer. Before discussing the above topics, it is beneficial to review the history of IBM[1] microcomputers.

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[1] IBM is a registered trademark of International Business Machines Corporation.

History of IBM Computers

Before Thomas Watson, Sr. changed its name from Calculating Tabulating Recording (CTR) to International Business Machine (IBM), CTR was primarily concerned with developing punch-card calculating and sorting machines in the United States (Veit, 1993).

IBM tradition

Thomas Watson was trained under National Cash Register (NCR) where he had demonstrated his management ability (Veit, 1993). The main tradition of IBM was to develop a sense of loyalty among employees and as long as this loyalty was in place, the company provided the best welfare for its organization. This policy was continued under the leadership of Thomas Watson, Jr. IBM's centralization is perhaps one of its unique characteristics among computer manufacturers.

Mainframe computers

Originally, neither developing microcomputers nor producing office typewriters were IBM's main or dominant areas. During the years following a transition from key punching devices, IBM's main business interest was largely concerned with mainframe computers (Veit, 1993). However, IBM also made computer peripherals and office typewriters. Initially, IBM leased computer equipment and provided the software as well as the hardware and peripherals.

In addition, a leasing option was available for those customers who were unable to buy the unit(s).

Personal computers

Many people believe that personal computers were developed in the early 1980s, however, this is not true. The first personal computer developed by IBM was, in fact, the IBM Model 5100 which was developed in early 1970s (Veit , 1993). The Model 5100 was a device which used a small digital cassette for program storage. It had 5-inch CRT and was capable of running BASIC and APL. It was not interfaced to a larger machine and it ran non-standard software. A hefty price of $10,000 kept it out-of-reach to most potential buyers. At that time IBM did introduce an improved mini-computer, the Model 5110, however, the development and improvement of small, personal computers were far from the company mainstream.

It wasn't until a construction article for the MITS Altair first appeared in *Popular Electronics* in January 1975, that the personal computer industry was born (Veit, 1993). IBM started to keep a careful eye on the development of the personal computer. During this 10-year period Apple Computers grew from a small garage operation to a major computer company with $2 billion in revenues. With the introduction of Apple II[2] computers and VisCalc in 1976, work formally done on IBM mainframes was being executed in offices on the

[2] Apple II is a registered trademark of Apple Corporation.

smaller personal computers. In 1980 IBM made a corporate decision to concentrate on building small computers in quantities. At first IBM had to start buying assembled units and parts from other companies, clearly a breakthrough into company tradition.

IBM, Intel and other computer manufacturers

A microprocessor is the heart of the computer, therefore, IBM chose the Intel[3] 8088 microprocessor for its new generation of computers. The 8088 chip is a 16-bit microprocessor with 8-bit address and it uses an 8086 instruction set. Until this time (1980-1981) it was not in IBM's tradition to use other manufacturers' parts, such as monitors and disk drives. However, to propel itself into the market, IBM had to quickly produce a personal computer. This eventually led to the development of the IBM PC Jr. which was later expanded to the IBM XT[4] and AT[5]. The operating system for the XT computers was designed by Microsoft and the printers were supplied by Epson[6]. Through extensive promotional advertising, IBM managed to market and sell a large number of computers either directly or through IBM dealers.

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[3] Intel is a registered trademark of Intel Corporation.

[4] XT stands for extended, since 640 kilo bytes of memory could have been installed into the system which at the time, however, seemed to be more than enough.

[5] AT stands for Advanced Technology.

[6] Epson is a registered trademark of Epson Corporation.

IBM compatible computers

The company reached a phenomenal height but the euphoria did not last long. Other manufacturers started to compete with IBM; however, IBM held copyrights on the ROM (Read Only Memory) BIOS[7] (Basic Input Output System) of its computers. This problem for competing manufacturers was soon solved by Phoenix[8] Development of Cambridge, Massachusetts through "reverse engineering". This technique allows a company to re-program the ROM chip in a way so that the function of the chip would remain the same (Veit, 1993).

AT computers

The AT (Advanced Technology) computers (also known as the 286 machines) were introduced in 1984. The advantage these machines were in their great speed and the fact that IBM used a new Intel chip, 80286, which had a 16-bit external bus. (The AT bus is also known as an ISA (Industry Standard Architecture bus). IBM enjoyed instant success and until about 1985, IBM was the only company manufacturing AT computers. In addition, IBM sold a large number of the faster AT computers to corporations who had been using the slower XTs for word-processing.

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[7] The BIOS (Basic Input Output System) contains specific information to make sure the computer is booted-up and functions properly. The information is programmed into an IC chip called ROM (Read Only Memory).

[8] Development of Cambridge of Massachusetts is a registered trademark of Phoenix Technologies Ltd. Corporation.

386 and 486 computers

Unlike the XT and 286 computers, the 386 computers were not a success for IBM. In fact, Compaq[9] was the first company that took advantage of Intel's 80386 and introduced a system using this chip. The 80386 chip had a 32-bit bus which was compatible with the 286 computers and it ran at higher speed. These computers were being marketed as early as 1987. Perhaps this was an important turning point in the history of personal computers--IBM was no longer leading the PC industry. Newer, faster 486 computers were developed. They were basically an integration of the 386 machines. The 486 took advantage of Intel's 80486 chip which had a co-processor built into it and ran faster than the 386 machine.

Pentium computers

The Pentium chip was first released on March 1993, however the chip was not available to the consumer until the last quarter of that year. This microprocessor is the only processor available in the market today that exceeds 100 MIPS (million instruction per second). It has two models: 60 and 66 Mhz (Halfhill, 1993). The performance of the CPU (central processing unit) alone for the 60Mhz chip is 1.6 times faster than the 486DX2 66Mhz (Greham, 1993). This processor has a 64-bit bus which, theoretically, should run the system twice as fast, however, in reality this is not always true (Ryan, 1993). While

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[9] Compaq is a registered trademark of Compaq Corporation.

the 80X86s were the dominant processors of the 80s, the Pentium processors will dominate 90s.

Studies Reporting Positive Effects of Computer Simulation

Eucker (1984) investigated the effects of three levels of system direction of learning approaches using computer simulation of an imaginary science. A sample of 63 Southern California high school students took part in the study. The three treatments varied from a full system assignment of the learning techniques to a no system assignment. The findings demonstrated that subjects under a full system assignment performed better than subjects given only a scheme of directions on the more complicated rules, but that there were no significant differences in overall scores or frustration ratings among the three treatment groups.

Using a computer simulation in finance, Dick (1985) wrote a computer-based management information simulation model and programmed it for use to study fiscal conditions affecting education in Ohio. The process was studied by identifying file elements and analyzing the program itself. The results of the study concluded that, although the model as developed provided the structure and documentation to plan full implementation, it was not feasible for an individual to maintain and support the model and that it was difficult to transfer the model and its programming language from one piece of computer hardware to another.

Coyle (1985) noted a gap between state-of-art educational research and what is practiced today. The majority of available Computer Assisted Learning (CAL) software at the time, however, lacked appropriate design features that would enable the computer to meet its potential for an infusion of problem solving, information processing, and model building skills into the current curriculum.

Knowing these problems, there were very few studies done about the effectiveness of computer simulation and its application in education or industry. This is probably due to the fact that, in the mid 1980s microcomputers were expensive and their capabilities were not as great as compared to what is available in the market today.

In terms of software, the same problem existed in the mid 1980s. Kronk (1985) performed a study to determine the effect of a computer simulated client on the learning of empathic responding. The results showed that the interaction with the client simulation was statistically significant. Treatment subjects had improved in written responses.

Borst (1985) investigated the assessment of concurrent, predictive, and construct validity and test-retest reliability of a computer simulation designed to test for control of variables as described by Inhelder and Piaget. The results indicated that, on the basis of the panel's evaluation and the statistical relationships between the computer simulation and the Pendulum Task[10], the technique had a degree of construct validity with the Pendulum Task. In addition, concurrent validity could also be established on the basis of non-parametric correlations. The results also established test-retest reliability and gender bias.

Woodward (1985) studied the effectiveness of computer simulation in magnifying student learning in a unit of health. The results showed significant differences on basic facts and concepts that were strengthened by the simulation. Differences were also noted on a maintenance test given two weeks after the posttest. The most significant difference was found in the test that measured problem solving skills.

Eisenkraft (1986) indicated that students[11] who received computer simulation were more successful at discerning functional relationship and scored higher on an achievement test than students who performed the traditional laboratory experiment. No significant difference was found in the students' ability to perform transfer tasks on actual laboratory experiments.

Kelley (1986) studied the use computer systems to replicate the army's new M1 tank. The results showed that soldiers who used a light pen and

[10] Statistical analysis was done by correlating the computer simulation scores with the Pendulum Task, the Lawson total score, the five Lawson sub-scores, and the ACS test scores.

[11] The subjects were 225 students enrolled in a high school physics course in three suburban high schools (Eisenkraft, 1986).

simulated test equipment could effectively troubleshoot the tank employing only the technical manual and video terminal display.

Hollingsworth (1987) analyzed students' results using computer simulation in health for a period of fourteen days. Students in both groups studied health using a traditional form of health curricula and also a computer health simulation. The findings showed that the treatment group scored significantly higher than the control group in achieving the defined objective, however, both groups scored significantly higher in the posttest than the pretest.

Krishnamachari (1988) reported how the use of computer simulations could be helpful to average mathematics students to understand basic concepts of probability. The results noted that students receiving simulation understood the concept of probability better than those who did not.

Carlsen (1989) investigated the effectiveness of computer simulation on student enrollment in freshman psychology courses. The results indicated a significant difference among the students receiving the simulation[12].

Hwang (1989) found that students using computer simulation individually would have a better score on the posttest as compared to those who worked with a partner. The results also indicated that students using

[12] An Apple Macintosh computer was used to perform the simulation.

computer simulation for computer numerical control received the same score on the posttest as the control group.

Willis (1989) studied the development and evaluation of a computer simulation, IRIS (Informal Reading Inventory Simulation), which can be used as an adjunct to classroom instruction on the administration and scoring of an Informal Reading Inventory. The results clearly support the use of computer simulation as an adjunct to traditional classroom instruction on the Informal Reading Inventory.

Kasow (1990) investigated the effect of computer simulation on 8th grade students. The findings showed that the students' social studies awareness was augmented by the use of the simulation. Although the results did not show an increase in the students' knowledge of mathematics concepts, a tendency toward an increase was apparent.

Students who were exposed to computer assisted cooperative learning (CACL) significantly gained in determining solutions and solving more computer simulation tasks (Butler, 1991). A second study reported in the same year (Kraft, 1991), lightning performance on a transmission system using PSpice, demonstrated that the PSpice program is, in fact, an excellent program to simulate lightning phenomenon on an electric power transmission line.

Studies Reporting Negative Effects of Computer Simulation

Park-Kim (1987) found that K-12 students have a negative direction in their attitudes towards computer simulation. The results for the experimental group in this study were not shown to be statistically significant, perhaps, because of the very small sample sizes.

Garren (1990) found that students using computer simulation in digital electronics showed less interest about the subject than those who did not receive computer simulation. However, the results from the posttests showed no significant difference between the group using simulation and the group using the actual components.

Studies Reporting No Effects due to Computer Simulation

Choi (1984) measured the effectiveness of computer simulation using the attributes of the microcomputer versus using parallel instruction consisting of hands-on laboratory experiences in the teaching of the concept of volume replacement. The results indicated that computer simulated experiences could substitute for hands-on laboratory experiences with an expectation of equal performance levels by students in approximately one-half the time needed for the hands-on laboratory experiences when including certain topics in secondary school science. This study also showed that a computer program could be used to replace more expensive devices or materials employed in many traditional hands-on laboratory experiments.

Hwang (1989) indicated that students working in pairs asked for less assistance from the teacher, allowing the teacher more time to conduct other tasks.

Shaw (1984) found that microcomputer simulations, laboratory activities, and a combination of the two instructional strategies resulted in greater accomplishment than customary classroom instruction. Neither achievement nor attitude differences were observed between the three treatment groups receiving computer simulations, laboratory activities, or a combination of the two.

Taylor (1984) evaluated the comparative efficiency of a shared campus arrangement, the Auraria Higher Education Center campus in downtown Denver, Colorado, by comparing the present operating system to simulated models of three hypothetical institutions operating independently from one another in split facilities. Five selected cost centers--general administration, library, student services, physical plant, and resident instruction--were compared by operating budgets. The results showed that no clear indication of efficiencies for cooperative as compared to independent operations was found.

Morgan (1986) noted that the group (NCE) not using computer estimation achieved significantly better scores than the computer estimation (CE) group. This study was conducted in a public elementary school.

Rohrbach and Stewart (1986) conducted research to certify the effect of using computer assisted instruction as compared to the lecture-discussion method in teaching principles and technique of cost recovery. The results indicated that the lecture-discussion technique was more effective than CAI in teaching the application of principles and concepts, and having experience with a computer had no effect on the students test scores.

Morgan (1987) reported no significant difference using computer simulation on student comprehension of a computer sorting algorithm when advanced organizers were employed during the instruction process.

Students who received computer simulation or laboratory experiments before the actual reading of the text, scored higher than those who read the text first (Gokhale, 1989). The results also indicated that there was no significant difference between the students who received computer simulation and those who received laboratory experiments in their achievement scores.

Kruse (1989) investigated the effectiveness of video disc or computer simulations of physics experiments. The results showed that there was no significant difference in the proficiency to control for variables, the number of measurements made during the investigation, or the success in finding a relation between variables being studied, by students using the two methods.

Cannaday (1990) studied the effect of computer assisted instruction on mathematics with a group of sixth graders. The results showed that no significant difference existed between the groups on enhancing student's performance on mathematics concepts, mathematics problems, mathematics computations, or mathematics total.

Nejad (1992) conducted a research study of the effect of computer simulation applied to sophomore level of electronics at Iowa State University. The results showed no difference between the group that used computer simulation and the group that did not. The results also indicated that the instructor does not have an effect on teaching the electronics material. Two instructors were involved during the teaching in that research. A recommendation suggested employing a lengthier period of study in basic level electronic courses.

Facts About Simulation

Ziegler (1985) reported that pre-service teachers were notably less knowledgeable about computer simulation than experts. Ziegler recommended training pre-service teachers in the evaluation of instructional computer software.

Larsen (1986) indicated that only the level of educational experience had a significant impact on persistence regarding computer simulation and suggested that computer simulations should be implemented in vocational programs.

Usage of computer simulation was shown to be an effective mechanism for decreasing student misconceptions in Physics (Lubert, 1986).

For problem-solving theory, cognitive development, and science teaching computer simulation plays a positive role (Lavoie, 1986).

Miller (1986) suggested that computer assisted instruction should be used in learning more complex topics. No significant difference was noted on simple topics using CAI (Miller, 1986).

Students and teachers have a positive reaction toward computer simulation (Hess, 1987). Apple II computers were used in an experiment that found gender to be irrelevant to the implementation of computer simulation (Hess, 1987). However, in another study, gender was a factor for implementation of computer simulation (Oringer, 1987). In Oringer's study, males seemed to score higher than the females. Perhaps the question still remains as to whether or not there is any correlation between the gender and computer simulation. Gender, age, and experience with computers were not related to student learning (Contant, 1987).

Connections between learning substances, social diversity in the computer learning environment, the role of the instructor in the computer learning environment, and the nature of the computer's "interactivity," are key distinguishing features of this technology (Mclellan, 1987).

In other studies of computer simulation use, Rowland (1988) indicated that computer simulations might be better at preparing learners for application tests.

Schmid (1989) investigated whether or not a one-computer classroom was as effective as a multi-computer classroom when giving a professionally designed social science simulation to average high school students. The results indicated that single-computer classes revealed consistently better attitudes toward computers after treatment than multi-computer classes.

Perhaps further class discussion, homework, and hands-on exercises also should be required to master the electricity and economic concepts embedded in the simulations (Rosner, 1989).

Educational institutions can save cost in implementing computer simulation laboratory experiments for selected engineering technology courses, as corresponding to "hands-on" experimental instruction provided by most traditional programs (Sehi, 1990).

Instructor implementation of a CAI innovation was challenging and complex process as reported in a case study of four special education teachers who implemented a staff development innovation of computer assisted instruction within their instructional programs (Zmurko, 1990).

The effect of computer assisted instruction on motivation and anxiety should be clarified within the context of other facts such as course grades, student gender, and student area of study (Hurt, 1991). The attitude of students toward computers is a complicated phenomenon, therefore, no obvious generalization concerning attitude toward computers can be truly applicable (Connell, 1991).

Thomas and Hooper (1991) indicated that:

> Currently, simulation research literature covers practically any computer program that is used for any purpose and supported in any manner. Until this confusion is removed, the potential of simulations will go

unrealized, and the morass of contradicting literature will continue to increase. (p. 510)

Computer Simulation Applications

As mentioned previously, computer simulation applications are not exclusively applied in the electronics area. Two examples of these practices in real life situations center around a concern about the ethanol fuel. Looker (1992) reported that :

> The president of the National Corn Growers Association Wednesday called on President Bush to approve by August 25, 1992 the use of ethanol fuels in cities with smog problems . . . Trotter[13] said the Environmental Protection Agency (EPA) has accepted the methods used for the study, which was based on a computer simulation of a smog alert in the Chicago metropolitan area. A similar study is being conducted on New York City airshed. (p. 10)

This study reflects actual usage of computer simulation in society. Another such example reported by Kasler (1992) is as follows:

> An Ames computer graphical company won a $1.9 million federal grant Tuesday to create an animation model of the human body. Engineering Animation Inc. (EAI) will team up with the Mayo Clinic to develop software for a three-dimensional computer simulation of a human being. The program will allow a user to 'peel back' layers of tissue and skin to several internal organs and observe the motion of tendons and muscles. (p. 8)

Morad and Beliveau (1991) stated that construction plans can be simulated by using the Computer Aided Design (CAD) and Artificial Intelligence (AI).

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[13] The president of the National Corn Growers Association.

There are many other examples about the usage of computer simulation. These examples indicate the following facts about the simulation techniques:

1. Computer simulation reduces the amount of time usually required to conduct the actual design, experiments, etc.
2. Computer simulation reduces the cost required for the actual design, experiment, etc.

PSpice Simulation Program

Many studies have been conducted using PSpice simulation. Several of these studies used this software for teaching various aspects of electronics technology. This section discusses the PSpice software and several studies that have been conducted using PSpice in different areas of electronics.

PSpice software

The software programs for computer simulation which were used in this study is called PSpice. There are many SPICE (Simulated Program with Integrated Circuit Emphasis) software available on the market. PSpice is one of the known software used in electronic simulation.

History of Spice   In the late 1970s and early 1980s there was a fascination for improving the quality of graphics and images in movies. The computer industry had just begun to focus on computer simulation (Sorensen, 1984). It is interesting to note that the Spice program started from a PhD dissertation at University of Berkeley in the late 1960s (Scott, 1989). In earlier versions of Spice the program collected information such as the value of resistors from the user and calculated the given information as if those components were a breadboard. MicroSim Corporation (the producer of PSpice) described the software as:

> PSpice is a member of the SPICE family of circuit simulators. The programs in this family come from the SPICE2 circuit simulation program developed at the University of California at Berkeley during the early 1970s . . . PSpice, the first SPICE-based simulator available on the IBM-PC, started being delivered in January of 1984. (MicroSim Corporation, *User's Guide*, 1992, p. 421)

Scott (1989) noted that:

> Spice was always capable of running on any type of computer. However, if you wanted to simulate a great number of nodes the program needed a great deal of computer power to produce results within a reasonable period of time. Ten years ago, for example, it was found only on mainframes at universities and large corporation, and you had to justify the cost of simulation time by citing the cost of IC fabrication. (p. 193)

When Version 4 of PSpice was released it contained a Digital Simulator Extension (DSE) which would allow the designers to run both analog and digital signals simultaneously (Milne, 1988). PSpice was about eight years old when it was first introduced to the market whereas the IBM-PC was 29 months old.

It seems that, while Spice was unavailable to the majority of designers about ten years ago, with the recent drastic reduction in the price of computer hardware it has become possible to bring this luxury into homes and offices of today.

<u>PSpice parameters</u> MicroSim Corporation, the developer of PSpice, has indicated that:

> PSpice allows you to simulate and test circuit design containing both analog and digital components without having to build the hardware equivalent . . . Pspice allows you to create a "computer breadboard" of the circuit for testing and refinement before actually having to build it. (MicroSim Corporation, *User's Guide,* 1992, p. 421)

During mid 1985 the SPICE program was introduced into the PC market right after Microsoft released Version 3 of its FORTRAN compiler (MicroSim Corporation, *Reference Manual*, 1992).

PSpice is mainly used for design purposes, however, it can also be used for circuit analysis. Monssen (1993) noted that "The advent of programs such as PSpice has profoundly altered the work-place for new engineering graduates" (p. iii).

Perhaps, if extra speed is required to simulate more complicated circuits on PSpice, an accelerator could be added to the PC (*Accelerator lts PC,* 1985).

PSpice as compared to other simulation software such as the Analyzer II and ECA-2 is much more expensive, however, PSpice has other advantages. It is user friendly, has libraries containing most parts, and is industry standard (Martin, 1989).

<u>Studies involving PSpice</u>

Many engineers now take advantage of simulating software such as PSpice. This practice saves considerable amount of time and effort for designing and testing purposes. There are other software programs available such as Micro-Cap, VHDL (Vantage Hardware Description Language), Electronics Workbench, SpiceNet, PreSpice, IsSpice, IntuScope, SPECS (Simulated Program for Electronics Circuit and Systems), SPICE2G3, ICAP/4[14] and Design Works that are used in computer simulation. However, the evaluation version[15] of PSpice can be obtained from MicroSim corporation at no cost for educational purposes. Micro-Cap III is used for analog circuit analysis (Berube, 1993).

Mokhtari (1992) conducted a study of the finite difference method (FDM) and indicated that:

> The FDM procedure applied to the modelisation of the electromagnetic wave propagation is a fast alternative procedure of the PSpice simulation for the calculation and phase along the coaxial cable in either the studied case of a linearly temperature dependent resistance or quadratic function. (p. 41)

Nehmadi (1990) researched the enhancement of magnetic pulse compression (MPC) employing PSpice to examine the experimental laser voltage and current wave forms. A conclusion of the study was,"The model helps us to obtain a better understanding of the CVL[16] drive circuit and it

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[14] This includes SpiceNet, PreSpice, IsSpice, and IntuScope.

[15] This is a short version of the actual software and it does not contain all the parts in the libraries.

[16] Copper Vapor Laser.

improves its efficiency by changing different electrical circuit parameters using the simulation program" (p. 3810).

Recently, MicroSim corporation began to change PSpice through the creation of The Design Center. The Design Center allows the operator to draw the circuit into page(s) and then run PSpice or Probe on it. This design center works on either Microsoft Windows or non-Windows environments (Donlin, 1992).

Gabay (1992) indicated that most simulation software are either analog or digital, and those with capabilities of running both cannot perform the operation simultaneously. However, PSpice has the capability of running both applications (analog and digital) at the same time (mixed mode of PSpice).

> Since the 1987 student version was written, the codes of the evaluation and production versions have been updated. These two versions now include a powerful digital option - that amongst other features - enables TTL and discrete components to be interconnected. (Stewart, 1992, p. 36).

Ahmad (1990) used PSpice to determine thermal gradients for a simple heat-sink plate where component power dissipation and ambient temperature are known. Through PSpice, the analysis was simplified by breaking the plate into groups of small elements.

Agnew (1991) indicated that there are very few studies reported in the literature about transducers, however, PSpice is one of the few software programs available that allows the designer to have the capability to accomplish such a task.

Many designers build and simulate their circuits by using the Spice simulation programs such as model thermistors (Hagerman, 1991), DC-DC converters power (Spearow, 1991), temperature to voltage convertors (Horace, 1990), fan controller[17], mechanical shock detectors (Sherman, 1990), number converting calculators (Reesor, 1990), simplifying Boolen expressions program (Kum, 1990) and the programmable frequency divider (Blackwell, 1991).

Most engineers working with servo and control-systems have used programs like ACSL[18] and Matrixx[19], however, these programs help the physical interpretation of the system, or its conceptualization (Vincent, 1991). PSpice is capable of doing the circuit topology in terms of basic components. "With a library of mechanical and electrical sub-circuits at your disposal, you can easily simulate a servo system comprising any number of nested sub-circuits" (Vincent, 1991, p. 123).

The computer simulation concept has also been recognized by the television industry. Radice (1991) noted, "You can use Spice-variety circuit-simulation software to model NTSC (National Television System Committee) video signals. You can then use these models to design and test video circuits" (p. 117).

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[17] This circuit would control the fan with respect to the temperature so the fan does not have to work at its maximum speed.

[18] ACSL is a registered trademark Mitchell and Gauthier Associates Corporation (Concord, MA).

[19] Matrixx is a registered trademark of Integrated Systems Inc.

Summary

Significant research has been conducted to date employing computer simulation, however, more studies need to be conducted to clarify the effect of computer simulation in teaching diverse subjects in a variety of learning situations. This is true especially in beginning level courses taught in colleges and universities. It should be also noted that the majority of research has been conducted in short periods of duration (two to eight weeks). Not many studies have been conducted over a longer period of time.

This topic of computer simulation has been identified as being of significance to teachers in providing them with the skills and knowledge necessary to effectively teach lessons in freshman electronic courses in college and universities.

CHAPTER III. MATERIALS AND METHOD

This study was a quasi-experimental research design and used a quantitative research design model. Therefore, the procedure of quantitative research was followed.

Overview of the Quasi-Experimental Research Design

This study involved two groups of ISU college students enrolled in a basic electronics course. The fundamentals of electricity such as direct current (DC) and alternative current (AC) were covered in this class. These fundamentals included only passive components. The results of achievement of the two groups were compared. One group received computer simulation to complement the actual traditional laboratory experiments while the other group received only the traditional laboratory experiments.

Population

The population who participated in this study were ISU college students enrolled in a basic electronics course[1]. Because of the need for a large sample[2] and time frame, a total of 76 students participated in this study (38 in each group). Students who enrolled in the Spring of 1992 were used as the control

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[1] The catalog name as of 1993 was Introduction to Electrical Energy (IEDT 140).

[2] Most studies relating to this topic in the past have used a small sample and were conducted over a short period of time.

group and students who enrolled in Fall of 1992 participated in this experiment as the treatment group. A copy of the ISU Human Subjects Committee Approval form is shown in Appendix A.

Location

This experiment took place in the Department of Industrial Education and Technology at Iowa State University of Science and Technology. Two laboratories located in the department were used to conduct this experiment: a) a computer laboratory located in IEDT Building II, Room 224; and b) an electronics laboratory located in IEDT Building II, Room 10A.

Limiting Conditions

This study was limited to the following factors:

1. Students who enrolled in the Spring of 1993 in IEDT 140; both sections A and B served as the control group.
2. Students who enrolled in the Fall of 1993 in IEDT 140; both sections A and B served as the experimental group.
3. PSpice Version 5.2 (the evaluation version) was used by the experimental group.
4. Seventy-six students participated in this study.
5. This study did not cover solid-state devices such as the diode, transistor, SCR . . . etc.
6. This study was limited to selected laboratory activities.

7. This study was limited to instruction provided by one instructor[3].
8. The materials covered in this study were related to theory with practical applications.
9. In the electronics laboratory students used a station to work in groups of two.
10. The text book used in this study was Fundamentals of Electricity by Floyd.

Sampling Technique

This study was a quasi-experimental design, therefore, the researcher had limited control over selection of the sample or population. Thirty-eight students who enrolled in IEDT 140, offered in the Spring of 1992, participated as the control group. Thirty-eight students enrolled in an intact class, IEDT 140, offered in the Fall of 1992, participated as the experimental group[4]. All students enrolled in Fall and Spring of 1992 participated in this study.

Procedures

Both groups were instructed using the same materials and topics. Twelve topics were covered in this study[5], with one lecture plus four hours of

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[3] Nejad (1992) stated the effect of the instructor is, in fact, insignificant.

[4] The exception being some students who might have dropped the course later on.

[5] These topics are listed under "Delimitations of the Study."

laboratory activities during each week. In the control group, all four hours used in laboratory activities were dedicated to practicing the theory discussed in the lecture, using the actual components to conduct the laboratory experiments.

In the experimental group, two out of four hours were used to implement the computer simulation and the remaining two hours were designated to utilizing the actual components in the laboratory activities. Petests were given at the beginning of the experiment to ensure unbiased sampling. A copy of simulation laboratory activities can be found in Appendix B.

At the beginning of each topic a take-home posttest (homework) was given related to the topic covered. All posttests were selected from the instructor/test bank manual which accompanied the text used in the class. Any interaction among students was impossible to control. At the end of each topic a posttest (quiz) was given related to the topic covered. After the introduction to AC (alternative current) another posttest was given covering all topics to that point. After covering all topics a final posttest was given containing questions from all topics covered. Student attendance in laboratory activities was monitored and compared. All tests included multiple-choice items. Students were informed of their scores and the correct answers to all tests except the final test for which only scores were provided. This practice was consistent with the university grading policy.

Materials

The test instrument employed in this study was chosen from the materials covered in the text. All administered tests remained the same for both the control and experimental groups. No question relating to computer simulation was given to both groups. Each take-home test consisted of 35 questions. Each posttest given at the end of every topic consisted of 20 questions. The test that was given at the end of the sixth topic consisted of 70 questions and the test that was given at the end of this study consisted of 100 questions.

Laboratory equipment

The laboratory equipment used in this study accommodated two groups: a) the traditional group; and b) the simulation group.

Traditional group The traditional group in this study used the following items in the electronics laboratory:

1. analog multimeter (three different types)
2. digital multimeter (three different types)
3. RLC (resistor, conductor, capacitor, etc.) meter
4. oscilloscope (50 Mhz)
5. resistors (1Ω-1MΩ)
6. capacitors (2200μF-22nf)
7. inductors

8. power supplies
9. signal generators
10. Frequency-meters

Simulation group In addition to the traditional group's equipment, the simulation group in this study used the following computers and software:

1. IBM compatible microcomputers (486 33Mhz)
2. Microsoft DOS Version 5.0
3. Microsoft Windows Version 3.1
4. Design Center Version 5.2 (developed by MicroSim)
5. PSpice Version 5.2 (developed by MicroSim)
6. Probe Version 5.2 (developed by MicroSim)

Human subjects

Human subject participated in this study. Forty ISU College students who were enrolled in IEDT 140 (*Fall semester*) participated as the control (traditional) group. Forty ISU students who were enrolled in IEDT 140 (*Spring semester*) participated as the experimental (simulation) group. Introduction to Electrical Enegry (IEDT 140) is offered by the Department of Industrial Education and Technology at Iowa State University of Science and Technology. Every subject participated in this study voluntarily. Their confidentiality was protected by all data being analyzed as group data and no identity of an individual is referenced. Class means were reported.

Data collection instruments

In order to measure the level of achievement between the experimental and control groups, several pretests and posttests were given to the subjects. A portion of these tests was take-home and the second portion was administered in-class.

Pretest This instrument was selected by the author. Pretests were given within the first two weeks of the experiment: a) A set of take-home pretests (homework) containing 49 question was given at the beginning of the second week (Monday) and was collected at the end of second week (Friday); b) A set of in-class (quiz) pretests containing 20 question was given at the end of the first week (Friday); c) A set of in-class pretests (quiz) containing 20 questions was given at the end of the second week (Friday). These pretests were given at different times and in sequence to ensure that the subjects had an adequate amount of time for their completion, and the amount of pressure due to test anxiety was intended to be minimized. A total 79 question was giving to the subjects as a pretest.

The pretest questions were related to the textbook materials and not to the computer simulation. A copy of these pretests can be found in Appendix C.

Posttest The posttests were also selected by the author. A total of 26 posttests was given to subjects. A portion of the posttests included take-home (homework) and the rest was administered in-class (quiz).

Homework A set of homework assignments was given to the subjects at the beginning of each weekly topic (Monday) before any laboratory activities were initiated and it was collected at the end of same week (Friday) after completion of all laboratory activities related to that topic. Each homework assignment contained 35 multiple-choice questions with at least one correct answer for each item. These questions were related to the materials covered in that weekly topic, and not to the computer simulation. A copy of these posttests can be found in Appendix D.

Quiz A set of quiz items was given to the subjects at the end of each weekly topic (Friday) before any laboratory activities and it was collected at the end of same week (Friday) after completion of all laboratory activities related to that topic. Each quiz contained 20 multiple-choice questions with at least one correct answer for each item. These questions were related to the materials covered in that weekly topic, and not to the computer simulation. A copy of these posttests can be found in Appendix E.

Midterm After covering five topics a midterm exam was given to the subjects. This exam contained 70 questions related to the topics covered. Two hours were designated for completion of this exam. A copy of the midterm exam can be found in Appendix F.

Final After covering all 12 topics a final exam was given to the subjects. This exam contained 100 questions related to the topics covered. Two hours was designated for completion of this exam. A copy of the final exam can be found in Appendix G.

Simulation program

The computer simulation used in this study was The Design Center, developed by MicroSim Corporation. This software requires a 286 personal computer or a more advanced system to run, with at least 3 megabytes of extended Random Access Memory (RAM). This version of The Design Center also requires Microsoft Windows 3.x to run. The Design Center consists of three programs: a) Schematics; b) PSpice; and c) Probe.

Schematics The Schematics program used in this study operates under Microsoft Windows Version 3.0 or higher (see Figure 1). The Schematics is defined as "the graphical circuit editor and manager for *PSpice* simulation and *Probe* analysis on Microsoft Windows and OpenWindows platform" (The Design Center: Circuit Analysis-User's Guide, 1992, p. 3). This program allows the user to draw the circuit using various parts in various libraries. After completion of the circuit, the ERC (Electrical Rule Check) ensures there is no pin floating in the circuit. The next step is to set up the program to run the specific analysis/analyses desired. This program generates two files; one with extension of "sch" which contains the circuit information for future retrieval. The other file contains a "net" (net-list file) extension which accommodates the circuit information and the analysis desired in a text file. All files saved in the older version would be retrievable in the later version of this software.

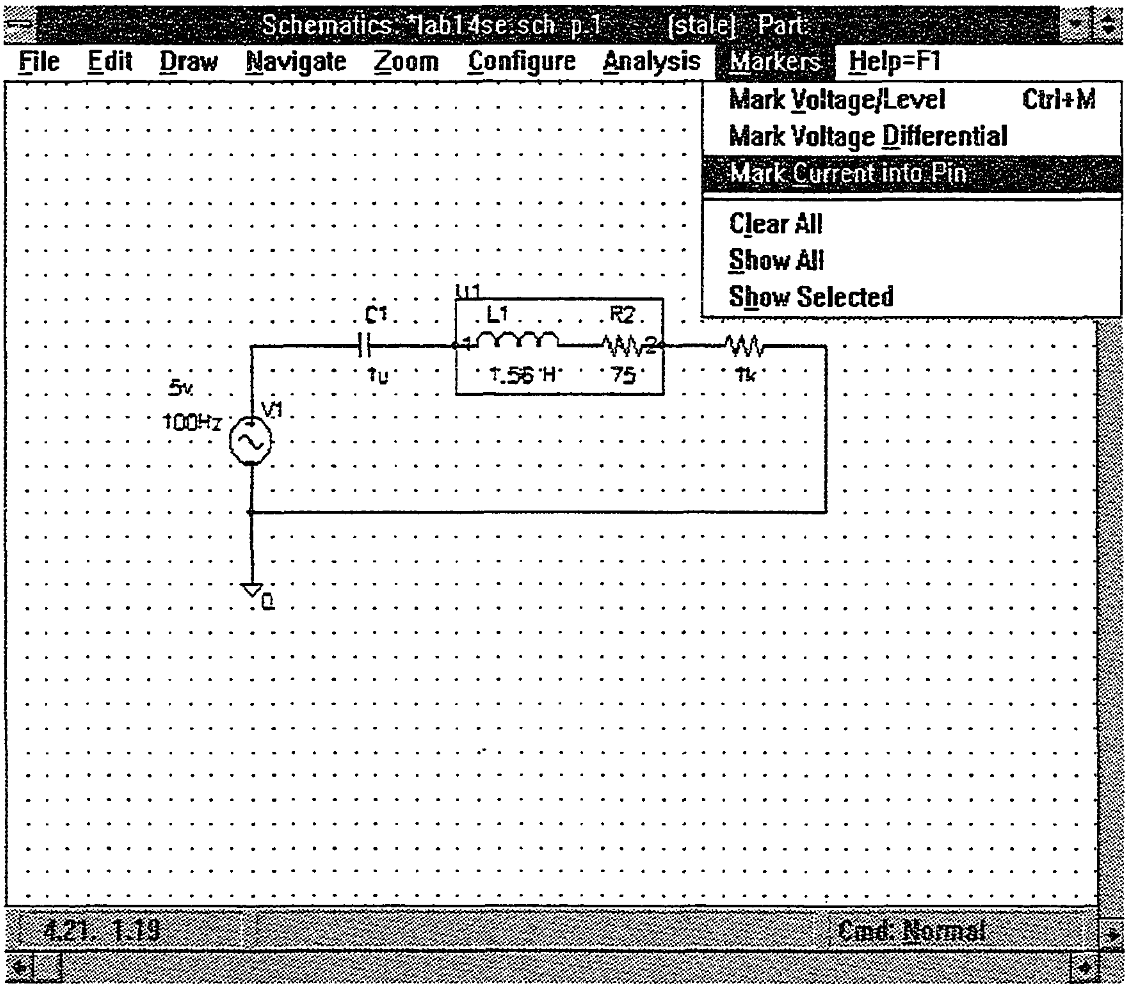

Figure 1. The design center's schematics capture program

<u>PSpice</u> The PSpice retrieves the information saved in net-list file and calculates the circuit analysis (D.C., A.C. or Transit) requested by the user (Figure 2). PSpice first checks the circuit and if there are no errors, it continues to perform the analysis. After completion of circuit analysis PSpice generates two files; one with the extension of "out" which contains the output information in the form of text. The other file contains a "dat" extension which accommodates graphical information desired to run the Probe.

<u>Probe</u> Probe is the graphical interface for Pspice. This program displays the analysis requested by the user in the form of graphs (Figure 3). Probe can display all the voltages and currents in the circuit which was calculated by PSpice earlier. Probe can be compared with the Digital Storage Oscilloscope which displays the desired voltages (Y axis) versus time (X axis). It can also be compared with the Spectrum analyzer which displays the desired voltages (Y axis) versus frequency (Y axis). In addition, the Probe can be used as a DC volt/amp meter.

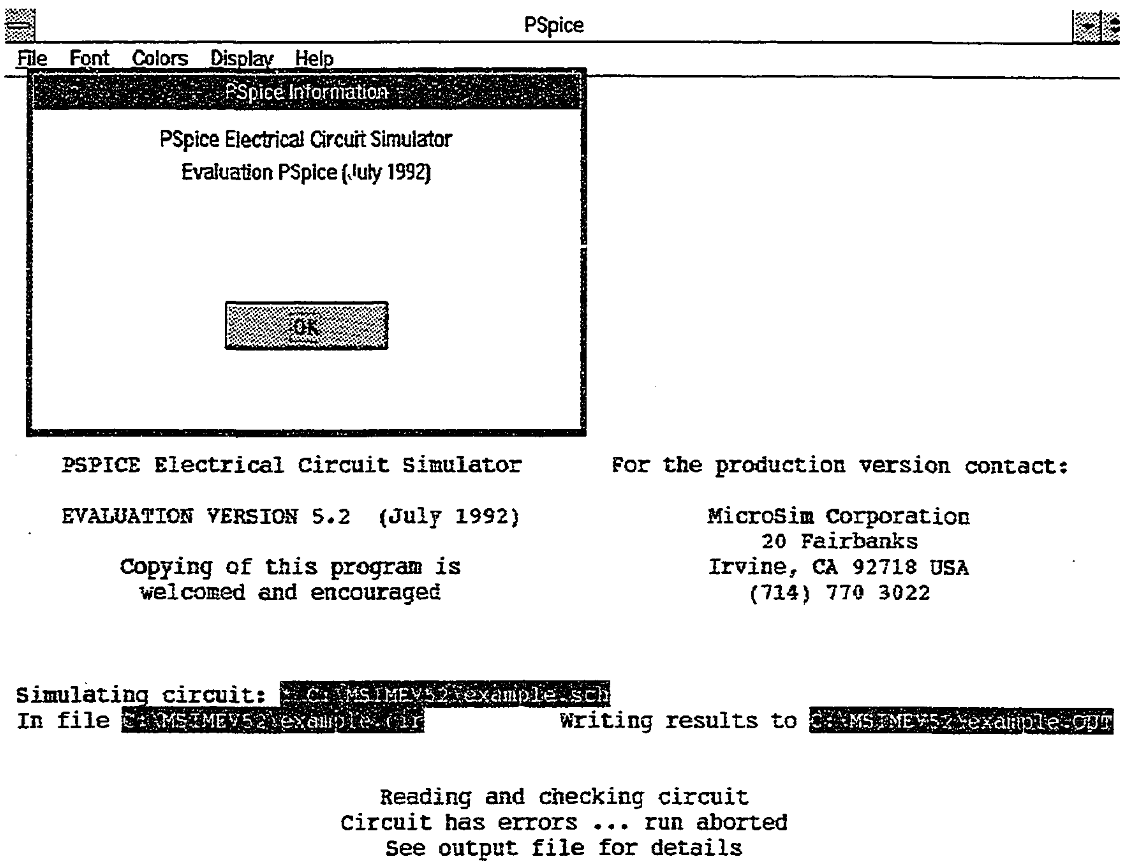

Figure 2. PSpice electrical circuit simulator

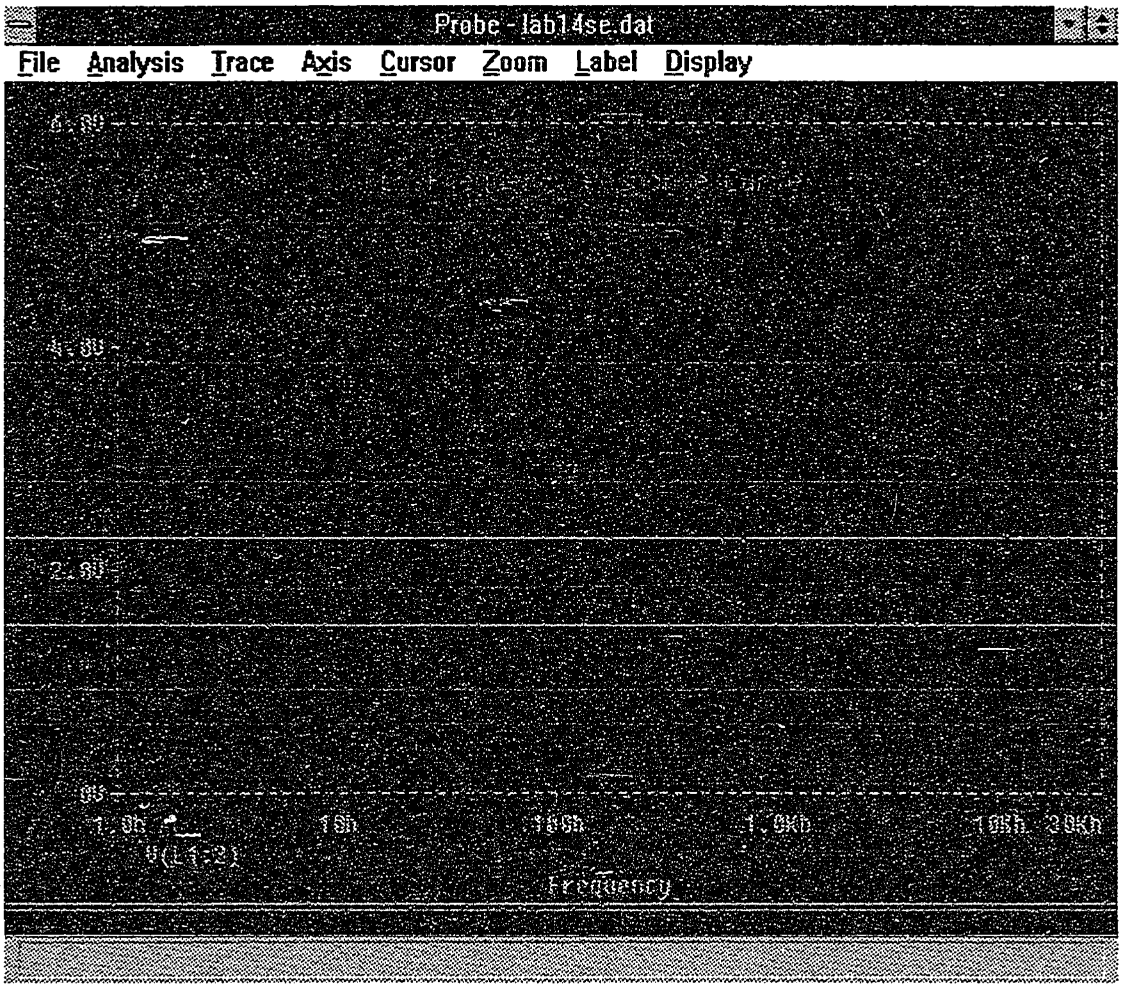

Figure 3. Probe program

Variables

The following dependent and independent variables were examined and studied.

Independent variables

1. Laboratory instructions using the actual components (traditional laboratory instruction).
2. Laboratory instructions using computer simulation in conjunction with using the actual components as a complement to reinforce learning.

Dependent variables

1. Take-home posttest 1-12.
2. In class posttest 1-12.
3. The mid-term posttest.
4 The final posttest.

Statistical Treatment

The analysis of variance (ANOVA) was used to determine the results.

1. A "2 X 12" ANOVA was used to compare the results of the take-home posttest (homework) 1-12.
2. A "2 X 12" ANOVA was used to compare the results of the in-class posttest (quiz) 1-12.

3. A "2 X 2" ANOVA was used to compare the results of the middle and final posttest.
4. Descriptive statistics of attendance of both groups in laboratory activity were reported.
5. The effects of attendance and pretest have been controlled by using an analysis of covariance (ANCOVA).

All student scores were recorded on the computer using LOTUS spreadsheet software. The SYSTAT and SPSSX software were used to analyze the data for this study.

Hypotheses of the Study

In this study the following hypotheses were tested:

Hypothesis I: There will be no significant difference between the mean scores of $PRE_{Exp.}$ (experimental averages) and $PRE_{Cnt.}$ (control averages).

Ho: $\mu_{E\ PRE} = \mu_{C\ PRE}$

Ha: $\mu_{E\ PRE} \neq \mu_{C\ PRE}$

Hypothesis II: There will be no significant difference between the mean scores[6] of $\mu_{E\ Q1}...\mu_{E\ Q12}$ (experimental averages) and $\mu_{C\ Q1}...\mu_{C\ Q12}$ (control averages).

Ho: $\mu_{E\ Q1}...\mu_{E\ Q12} = \mu_{C\ Q1}...\mu_{C\ Q12}$

Ha: $\mu_{E\ Q1}...\mu_{E\ Q12} \neq \mu_{C\ Q1}...\mu_{C\ Q12}$

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[6] The mean scores represented are from the posttest given after each topic.

Hypothesis III: There will be no significant difference between the mean scores of $\mu_{E\ H1} \ldots \mu_{E\ H12}$ (experimental averages) and $\mu_{C\ H1} \ldots \mu_{C\ H12}$ (control averages). The mean scores represented are from the posttest which was given at the beginning of each topic and collected before the new topic had begun.

Ho: $\mu_{E\ H1} \ldots \mu_{E\ H12} = \mu_{C\ H1} \ldots \mu_{C\ H12}$

Ha: $\mu_{E\ H1} \ldots \mu_{E\ H12} \neq \mu_{C\ H1} \ldots \mu_{C\ H12}$

Hypothesis IV: There is no significant difference between the mean scores of $\mu_{E\ MID}$, (experimental averages) and $\mu_{C\ MID}$, (control averages).

Ho: $\mu_{E\ MID} = \mu_{C\ MID}$

Ha: $\mu_{E\ MID} \neq \mu_{C\ MID}$

Hypothesis V: There is no significant difference between the mean scores of $\mu_{E\ FIN}$, (experimental averages) and $\mu_{C\ FIN}$, (control averages).

Ho: $\mu_{E\ FIN} = \mu_{C\ FIN}$

Ha: $\mu_{E\ FIN} \neq \mu_{C\ FIN}$

Hypothesis VI: There is no significant difference between the mean scores of $\mu_{E\ DIF}$, (experimental averages) and $\mu_{C\ DIF}$, (control averages).

Ho: $\mu_{E\ DIF} = \mu_{C\ DIF}$

Ha: $\mu_{E\ DIF} \quad \mu_{C\ DIF}$

Hypothesis VII: There is no significant difference between the students' attendances of the experimental and the control group.

Ho: $\mu_{E\ ATT.} = \mu_{C\ ATT.}$

Ha: $\mu_{E\ ATT.} \neq \mu_{C\ ATT.}$

CHAPTER IV. RESULTS

In this chapter, the results and finding are presented. The following sections are covered to ensure the accuracy of data analysis: a) Power Analysis; b) Descriptive Statistics; and c) Inferential Statistics. Power analysis describes whether or not the study had an adequate sample size. Descriptive statistics describe the general statistical measures such as mean, median, mode, etc. Inferential statistics provide the answers to research questions and hypotheses discussed in Chapter I and Chapter III.

Power Analysis

Power analysis in statistics helps to determine the sample size required for the experimental research. Howell (1987) indicated that:

> Speaking in terms of Type II error it is a rather negative way of approaching the problem, since it keeps reminding us that we might make a mistake. The more positive approach would be to speak in terms of **power** which is defined as the probability of correctly rejecting a false H_0. Thus power = 1 - β. A more powerful experiment is one that has a better chance of rejecting a false H_0 than does a less powerful experiment. (p. 194)

Usually the major concern about finding an error is when the researcher fails to reject the null hypothesis, however, retaining the null hypothesis when it should have been rejected, can also be as vital to the researcher. Both Type I and Type II error were into consideration in this study.

Howell (1987) suggested the following formula to determine the effect size (γ):

γ = effect-size

μ = population mean

$$\gamma = \frac{\mu_1 - \mu_0}{\sigma}$$

σ = standard deviation (population)

The σ of pervious quizzes was 2.9425 and μ_0 = 14.9964. If a researcher expects an approximate gain of 15% which would result in μ_1 to be 17.2459, therefore, the effect size would be:

$$\gamma = 0.7644 = \frac{17.2459 - 14.9965}{2.9425}$$

Howell (1987) also suggested the following formula to determine the power for a two-tailed test:

γ = effect-size

N = sample size

$$\delta = \gamma\sqrt{\frac{N}{2}}$$

$\delta = (\gamma)(f(N))$

The above equation results in δ to be 3.2430. Using Howell's (1987) method, when δ = 3.2430, therefore the power would be .89 at α = .05 which is above .80 and high enough for this study.

$$\delta = 3.2430 = 0.7644\sqrt{\frac{36}{2}}$$

Descriptive Statistics

In this section with the help of figures and tables the descriptive statistics is discussed. In Table 1 and Figures 4 and 5 the descriptive statistics resulting from the pretests are shown. Tables 2-8 and Figures 6-19 indicate the descriptive statistics for quizzes, homework, attendance, midterm and final.

Table 1. Pretest descriptive statistics

Groups	Control	Experimental
Number of Cases	38	38
Minimum	67.000	64.000
Maximum	87.000	87.000
Range	20.000	23.000
Mean	79.255	78.395
Variance	20.388	35.651
Standard Deviation	4.515	5.971
Standard Error	0.732	0.969
Sum	3011.700	2979.000
Critical Value	0.057	0.076
Median	80.880	80.500

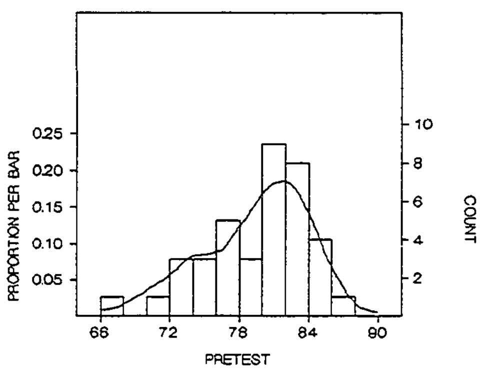

Figure 4. Control group pretest histogram

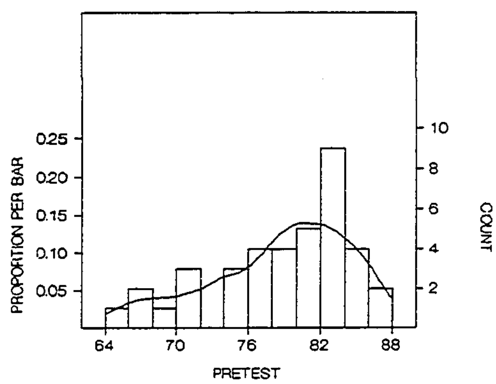

Figure 5. Experimental group pretest histogram

Table 2. Quiz 1-4 descriptive statistics

	Quiz 1	Quiz 1	Quiz 2	Quiz 2	Quiz 3	Quiz 3	Quiz 4	Quiz 4
Groups	Cnt.	Exp.	Cnt.	Exp.	Cnt.	Exp.	Cnt.	Exp.
Number of Cases	38	38	38	38	38	38	38	38
Minimum	13.000	9.000	15.000	13.000	14.000	9.000	9.000	8.000
Maximum	20.000	20.000	20.000	20.000	20.000	20.000	19.000	20.000
Range	7.000	11.000	5.000	7.000	6.000	11.000	10.000	12.000
Mean	17.737	16.684	17.686	17.401	19.026	18.263	15.243	13.889
Variance	2.848	7.952	2.280	2.512	1.756	5.605	6.671	5.988
Standard Dev.	1.688	2.820	1.510	1.585	1.325	2.367	2.583	2.447
Standard Error	0.274	0.457	0.245	0.257	0.215	0.384	0.419	0.397
Skewness (G1)	-0.742	-1.007	-0.252	-0.600	-1.885	-2.016	-0.425	0.467
Kurtosis (G2)	0.118	0.337	-1.143	0.397	3.999	4.560	-0.536	1.091
Sum	674.00	634.00	679.00	661.24	723.00	694.00	579.00	527.78
Critical Value	0.95	0.169	0.084	0.091	0.070	0.130	0.169	0.176
Median	18.000	17.000	18.000	17.620	19.000	19.000	16.000	13.945

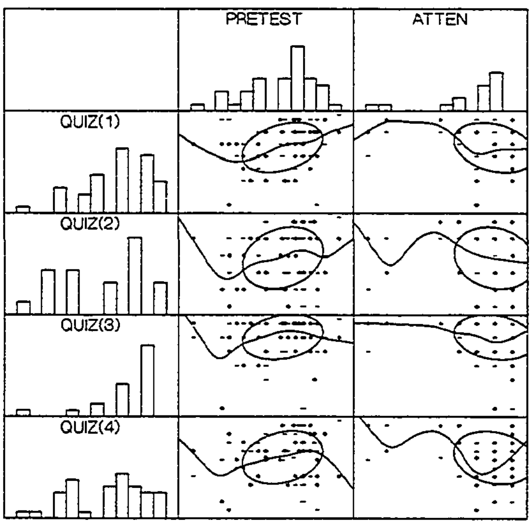

Figure 6. Quiz 1-4 control group density graph

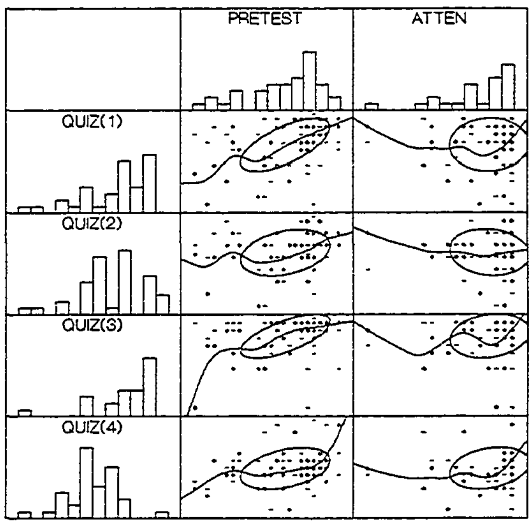

Figure 7. Quiz 1-4 experimental group density graph

Table 3. Quiz 5-8 descriptive statistics

	Quiz 5	Quiz 5	Quiz 6	Quiz 6	Quiz 7	Quiz 7	Quiz 8	Quiz 8
Groups	Cnt.	Exp.	Cnt.	Exp.	Cnt.	Exp.	Cnt.	Exp.
Number of Cases	38	38	38	38	38	38	38	38
Minimum	10.000	8.000	11.000	7.000	12.000	9.000	7.000	9.000
Maximum	19.000	19.000	20.000	19.000	19.000	19.000	20.000	19.000
Range	9.000	11.000	9.000	12.000	7.000	10.000	13.000	10.000
Mean	16.684	15.171	16.553	14.833	16.395	15.781	16.000	15.376
Variance	4.006	5.107	3.930	6.135	3.056	7.229	7.351	4.689
Standard Dev.	2.0001	2.260	1.982	2.477	1.748	2.689	2.711	2.165
Standard Error	0.325	0.367	0.322	0.402	0.284	0.436	0.440	0.351
Skewness (G1)	-1.341	-0.857	-0.733	-0.855	-0.468	-0.988	-1.187	-1.050
Kurtosis (G2)	2.002	1.095	0.106	1.057	-0.502	0.288	1.713	1.170
Sum	634.00	576.00	629.00	563.00	623.00	599.68	608.00	584.28
Critical Value	0.120	0.149	0.120	0.167	0.107	0.170	0.169	0.141
Median	17.000	15.170	17.000	15.000	17.000	16.000	17.000	15.380

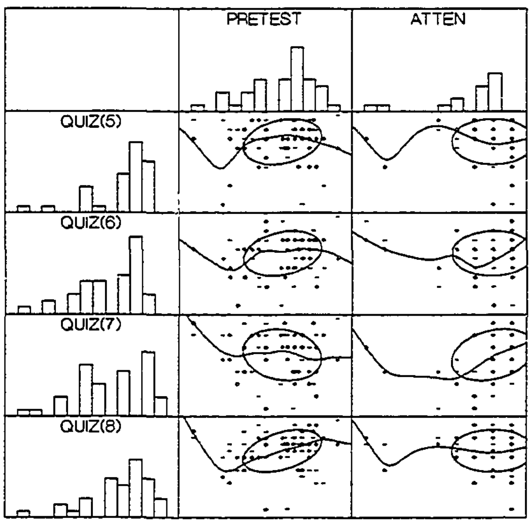

Figure 8. Quiz 5-8 control group density graph

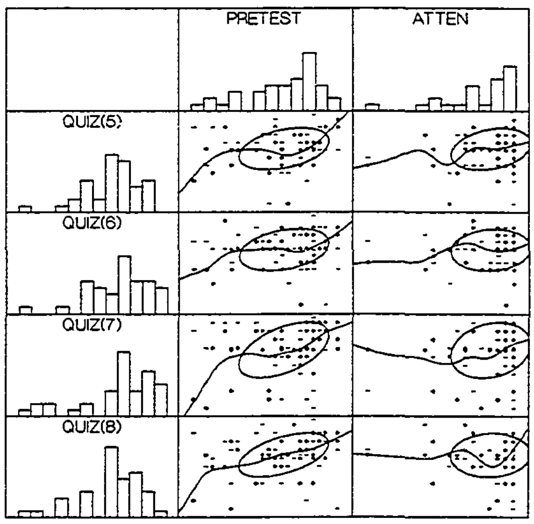

Figure 9. Quiz 5-8 experimental group density graph

Table 4. Quiz 9-12 descriptive statistics

	Quiz 9	Quiz 9	Quiz10	Quiz10	Quiz11	Quiz11	Quiz12	Quiz12
Groups	Cnt.	Exp.	Cnt.	Exp.	Cnt.	Exp.	Cnt.	Exp.
Number of Cases	38	38	38	38	38	38	38	38
Minimum	10.000	8.000	11.000	7.000	12.000	9.000	7.000	9.000
Maximum	19.000	19.000	20.000	19.000	19.000	19.000	20.000	19.000
Range	9.000	11.000	9.000	12.000	7.000	10.000	13.000	10.000
Mean	16.684	15.171	16.553	14.833	16.395	15.781	16.000	15.376
Variance	4.006	5.107	3.930	6.135	3.056	7.229	7.351	4.689
Standard Dev.	2.0001	2.260	1.982	2.477	1.748	2.689	2.711	2.165
Standard Error	0.325	0.367	0.322	0.402	0.284	0.436	0.440	0.351
Skewness (G1)	-1.341	-0.857	-0.733	-0.855	-0.468	-0.988	-1.187	-1.050
Kurtosis (G2)	2.002	1.095	0.106	1.057	-0.502	0.288	1.713	1.170
Sum	634.00	576.00	629.00	563.00	623.00	599.68	608.00	584.28
Critical Value	0.120	0.149	0.120	0.167	0.107	0.170	0.169	0.141
Median	17.000	15.170	17.000	15.000	17.000	16.000	17.000	15.380

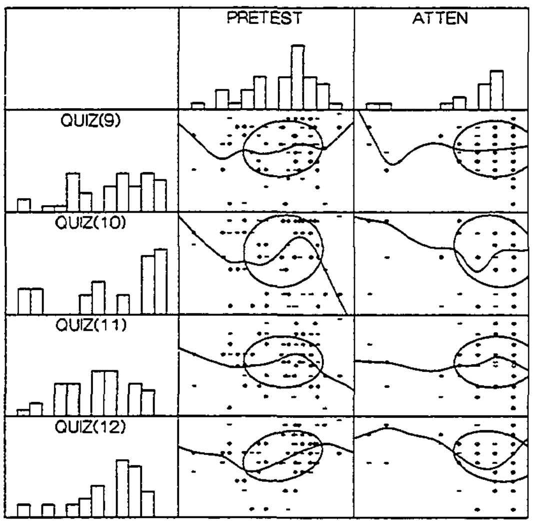

Figure 10. Quiz 9-12 control group density graph

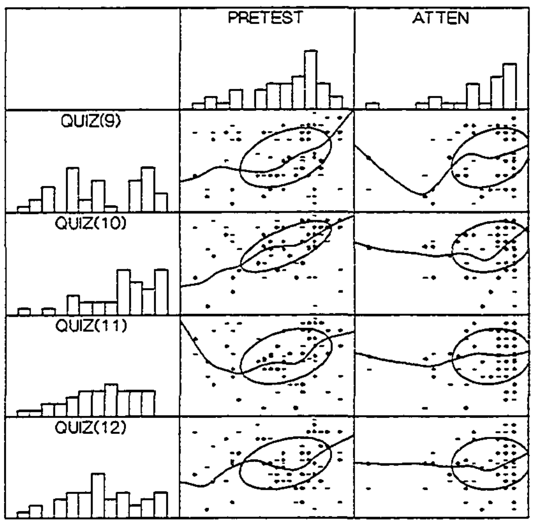

Figure 11. Quiz 9-12 experimental group density graph

Table 5. Homework 1-4 descriptive statistics

	HW 1	HW 1	HW 2	HW 2	HW 3	HW 3	HW 4	HW 4
Groups	Cnt.	Exp.	Cnt.	Exp.	Cnt.	Exp.	Cnt.	Exp.
Number of Cases	38	38	38	38	38	38	38	38
Minimum	24.000	21.000	29.000	23.000	24.000	17.000	21.000	15.000
Maximum	34.000	35.000	35.000	35.000	35.000	35.000	33.000	34.000
Range	10.000	14.000	6.000	12.000	11.000	18.000	12.000	19.000
Mean	30.297	29.678	32.784	31.297	32.243	30.000	26.921	24.583
Variance	5.290	13.618	2.602	10.209	7.914	24.000	10.291	16.291
Standard Dev.	2.300	3.690	1.613	3.195	2.813	4.937	3.208	1.036
Standard Error	0.373	0.599	0.262	0.518	0.456	0.801	0.520	0.655
Skewness (G1)	-0.762	-0.721	-0.464	-0.884	-1.234	-1.237	0.062	-0.001
Kurtosis (G2)	0.029	-0.275	-0.452	-0.218	1.096	0.903	-0.765	0.140
Sum	1151.3	1127.7	1245.7	1189.3	1225.2	1140.0	1023.0	934.16
Critical Value	0.076	0.124	0.049	0.102	0.087	0.165	0.119	0.164
Median	31.000	30.500	33.000	32.000	33.000	32.000	27.000	25.000

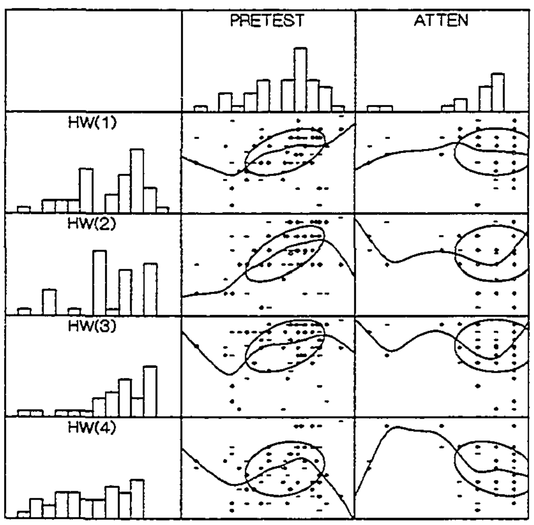

Figure 12. Homework 1-4 control group density graph

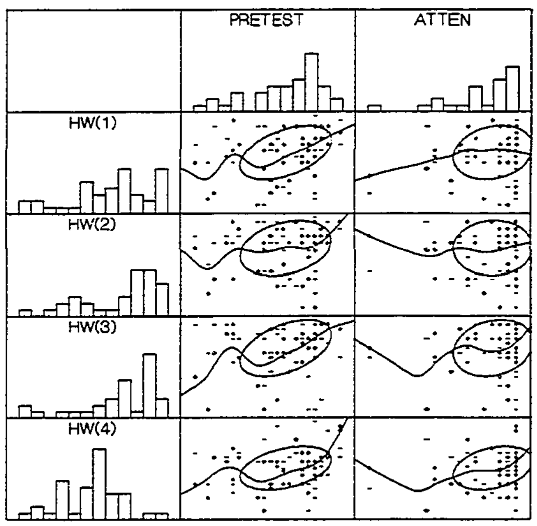

Figure 13. Homework 1-4 experiment. group density graph

Table 6. Homework 5-8 descriptive statistics

	HW 5	HW 5	HW 6	HW 6	HW 7	HW 7	HW 8	HW 8
Groups	Cnt.	Exp.	Cnt.	Exp.	Cnt.	Exp.	Cnt.	Exp.
Number of Cases	38	38	38	38	38	38	38	38
Minimum	20.000	12.000	20.000	17.000	24.000	19.000	22.000	20.000
Maximum	34.000	35.000	32.000	34.000	34.000	35.000	33.000	35.000
Range	14.000	23.000	12.000	17.000	10.000	16.000	11.000	15.000
Mean	28.541	27.222	28.000	27.250	30.000	30.118	28.763	28.829
Variance	13.221	28.817	11.189	17.966	7.184	13.014	12.672	15.810
Standard Dev.	3.363	5.368	3.345	4.239	2.680	3.608	3.560	3.976
Standard Error	0.590	0.871	0.543	0.688	0.435	0.585	0.577	0.645
Skewness (G1)	-0.146	-0.737	-0.992	-0.358	-0.604	-1.305	-0.327	-0784
Kurtosis (G2)	-0.612	0.312	-0.008	-0.780	-0.456	1.243	-1.221	-0.268
Sum	1084.5	1034.4	1064.0	1035.5	1151.0	1144.4	1093.0	1095.4
Critical Value	0.127	0.197	0.119	0.156	0.088	0.120	0.124	0.138
Median	28.000	27.610	29.000	27.625	31.000	30.560	29.500	30.000

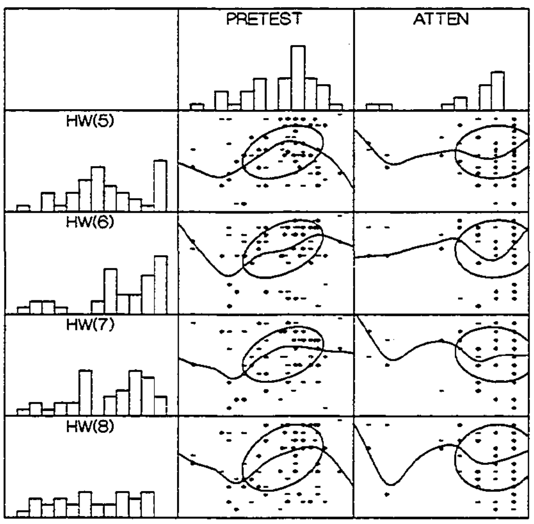

Figure 14. Homework 5-8 control group density graph

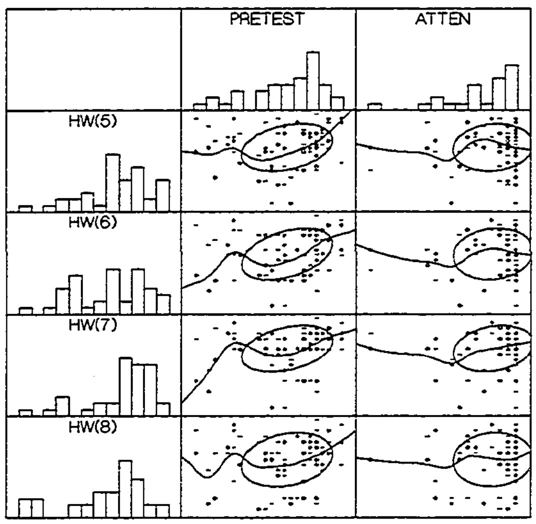

Figure 15. Homework 5-8 experiment. group density graph

Table 7. Homework 9-12 descriptive statistics

	HW 9	HW 9	HW10	HW10	HW11	HW11	HW12	HW12
Groups	Cnt.	Exp.	Cnt.	Exp.	Cnt.	Exp.	Cnt.	Exp.
Number of Cases	38	38	38	38	38	38	38	38
Minimum	17.000	18.000	22.000	12.000	20.000	22.000	18.000	14.000
Maximum	35.000	35.000	32.000	35.000	35.000	35.000	34.000	35.000
Range	18.000	17.000	10.000	23.000	15.000	13.000	16.000	21.000
Mean	28.944	27.823	27.778	27.730	29.323	27.865	27.711	26.829
Variance	11.511	20.728	6.438	23.603	11.931	14.171	16.752	21.378
Standard Dev.	3.393	4.553	2.537	4.858	3.454	3.764	4.093	4.624
Standard Error	0.550	0.739	0.412	0.788	0.560	0.611	0.664	0.750
Skewness (G1)	-1.075	-0.646	-0.541	-1.470	-1.071	0.181	-0575	-0.592
Kurtosis (G2)	2.414	-0.619	-0.451	2.592	1.490	-0.766	-0.542	0.247
Sum	1099.8	1057.2	1055.5	1053.7	1114.2	1058.8	1053.0	1019.4
Critical Value	0.117	0.164	0.091	0.175	0.118	0.135	0.148	0.172
Median	29.000	28.410	28.000	29.000	29.660	28.000	28.500	27.000

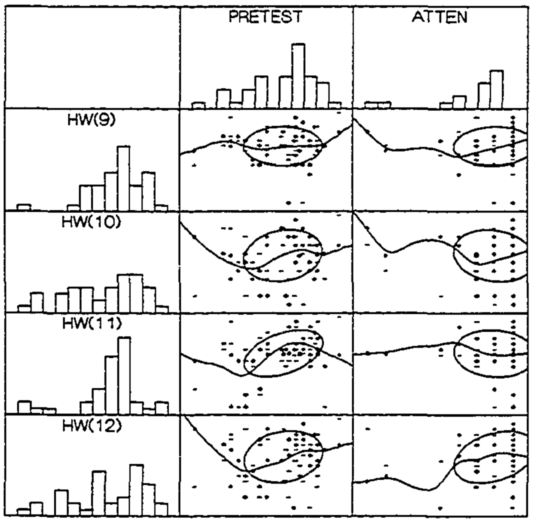

Figure 16. Homework 9-12 control group density graph

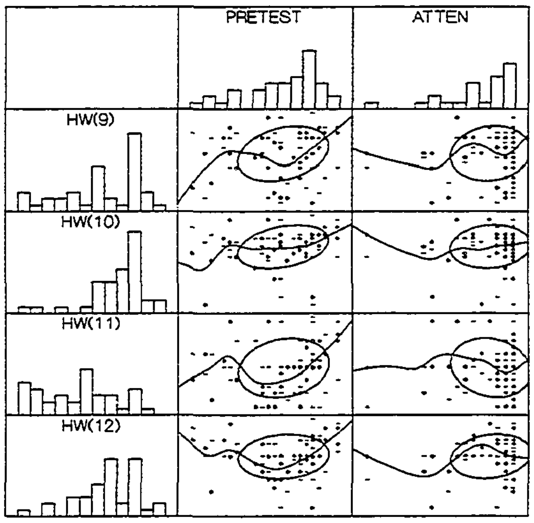

Figure 17. Homework 9-12 experimental group density graph

Table 8. Attendance, midterm and final descriptive statistics

	Atten.	Atten.	Midterm	Midterm	Final	Final
Groups	Cnt.	Exp.	Cnt.	Exp.	Cnt.	Exp.
Number of Cases	38	38	38	38	38	38
Minimum	11.000	6.000	77.143	54.286	63.000	37.000
Maximum	15.000	15.000	94.286	95.714	92.000	94.000
Range	4.000	9.000	17.143	41.429	29.000	57.000
Mean	14.487	13.579	88.0.45	85.301	77.526	72.389
Variance	0.871	4.196	21.889	81.512	58.851	165.150
Standard Dev.	0.934	2.048	4.679	9.028	7.671	12.851
Standard Error	0.151	0.332	0.759	1.465	1.244	2.085
Skewness (G1)	-2.411	-1.857	-0.659	-1.835	-0.037	-0.859
Kurtosis (G2)	5.626	3.382	-0.305	3.716	-0.932	0.616
Sum	550.500	516.000	3345.714	3241.429	2946.000	2750.78
Critical Value	0.064	0.151	0.053	0.106	0.099	0.178
Median	15.000	14.500	88.571	87.143	79.000	73.000

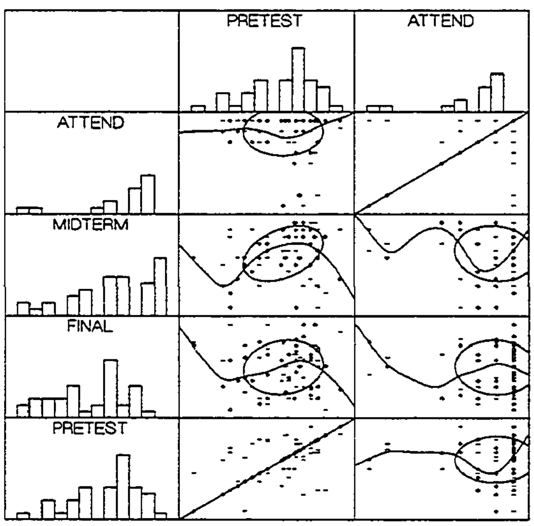

Figure 18. Attendance, midterm, final and pretest control group density graph

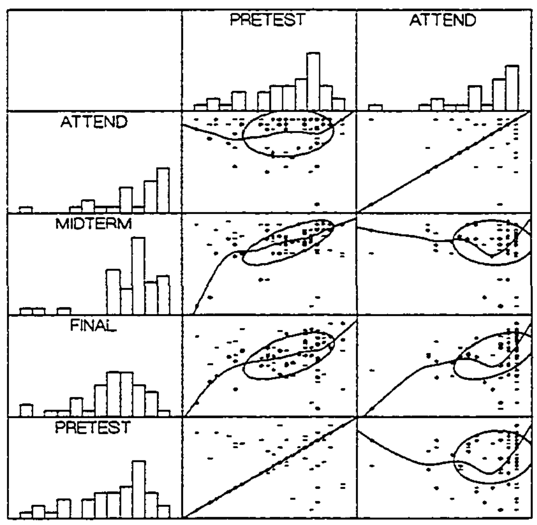

Figure 19. Attendance, midterm, final and pretest experimental group density graph

Figure 20 represents a three dimensional graph which illustrates the relationship between the attendance and midterm in the control group. Figure 21 provides the same information for the experimental group. A Kernel smoothing (shows where the data is concentrated) has been used.

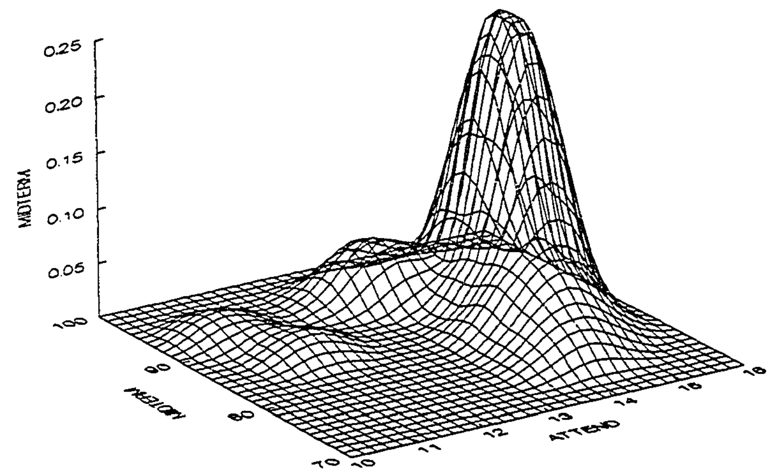

Figure 20. Kernel density estimator of attendance and midterm (control group)

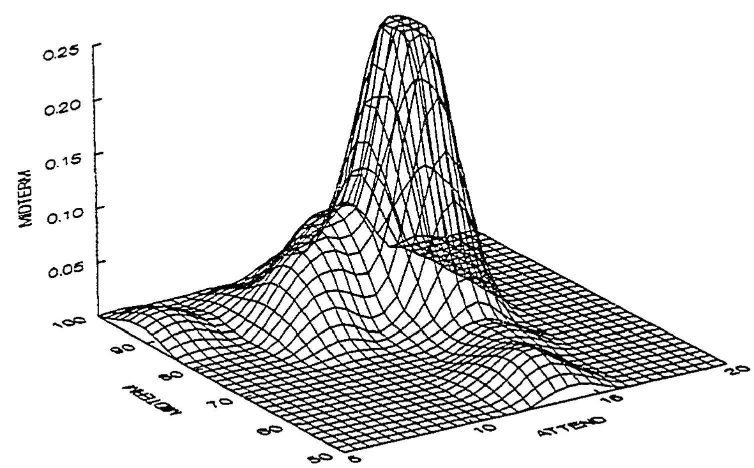

Figure 21. Kernel density estimator of attendance and midterm (experimental group)

Figure 22 provides a three dimensional graph which illustrates the relationship between the attendance and midterm in the control group. Figure 23 provides the same information for the experimental group. A Kernel smoothing (shows where the data is concentrated) has been used.

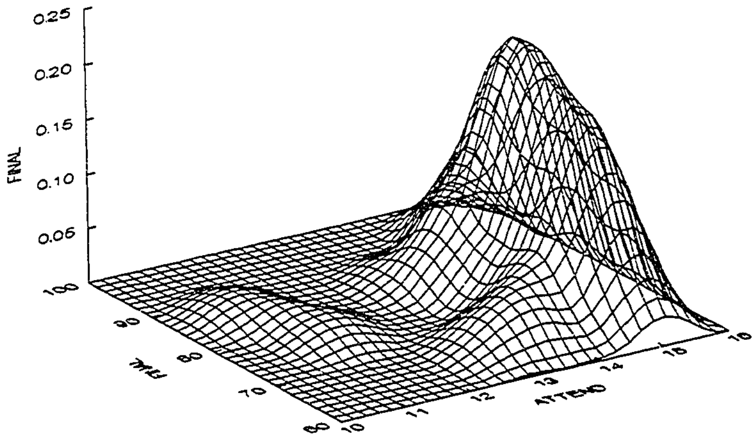

Figure 22. Kernel density estimator of attendance and final (control group)

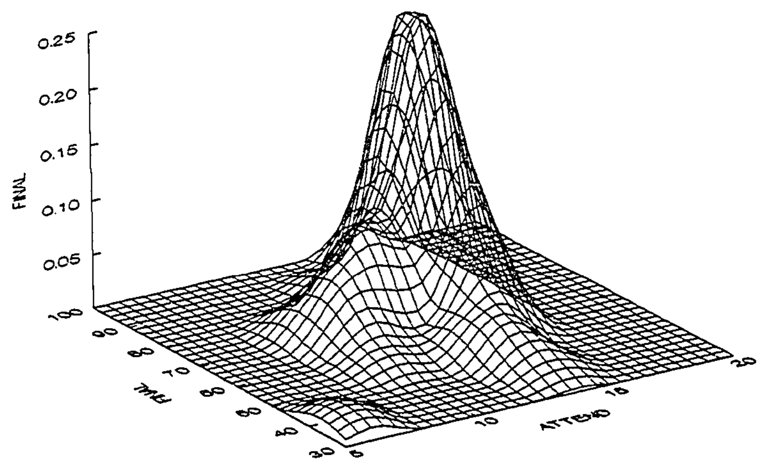

Figure 23. Kernel density estimator of attendance and final (experimental group)

Figure 24 provides a three dimensional graph which illustrates the relationship between the attendance and the average quiz score in the control group. Figure 25 provides the same information for the experimental group. A Kernel smoothing (shows where the data is concentrated) has been used.

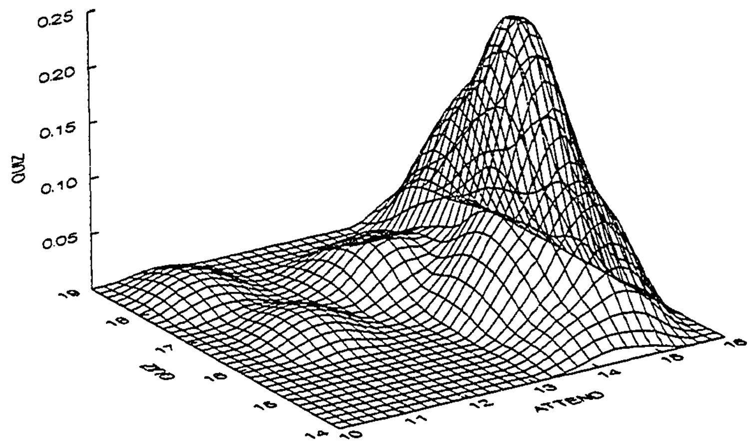

Figure 24. Kernel density estimator of attendance and quizzes (control group)

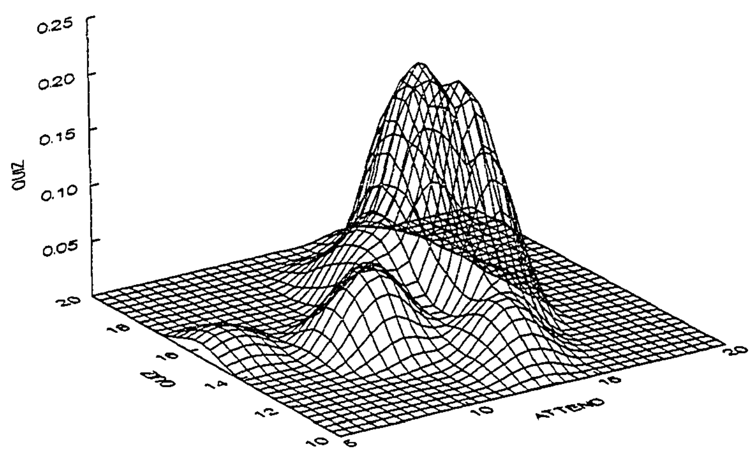

Figure 25. Kernel density estimator of attendance and quizzes (experimental group)

Figure 26 provides a three dimensional graph which illustrates the relationship between the attendance and the average homework score in the control group. Figure 27 provides the same information for the experimental group. A Kernel smoothing (shows the data concentration) has been used.

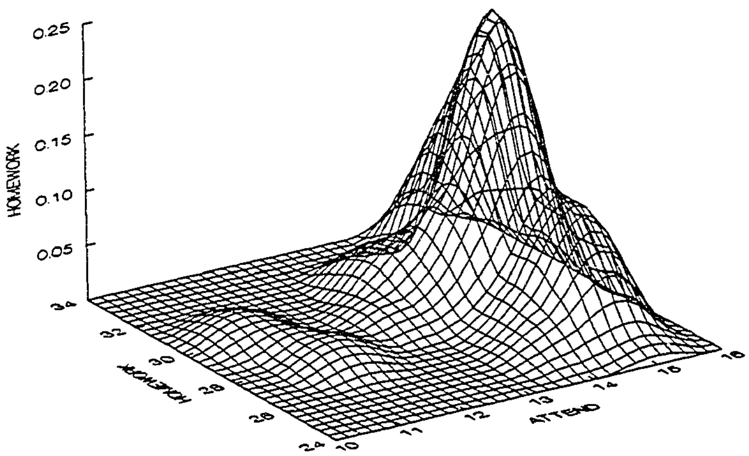

Figure 26. Kernel density estimator of attendance
and homeworks (control group)

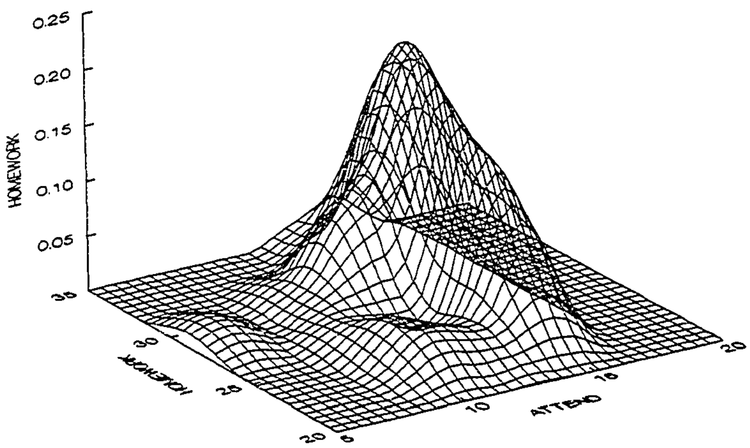

Figure 27. Kernel density estimator of attendance
and homeworks (experimental group)

Inferential Statistics

This section is devoted to the tests of research hypotheses. Seven hypotheses were discussed in chapter III, these hypotheses are presented and relevant materials are discussed in considerable detail.

Hypothesis I

There will be no significant difference between the mean scores of $PRE_{Exp.}$ (experimental averages) and $PRE_{Cnt.}$ (control averages).

Ho: $\mu_{E\ PRE} = \mu_{C\ PRE}$

Ha: $\mu_{E\ PRE} \neq \mu_{C\ PRE}$

A t-test was used for the comparison between the scores of the pretest for the two groups. The results of the t-test are shown in Table9.

The pretest mean for the control group was 79.25, while the mean for the experimental group was 78.39. The standard deviation for the control group was 4.515, whereas, the mean for the experimental group was 5.971.

Table 9. The t-test between the pretest of control and experimental group

Group	N	Mean	SD	T	DF	P
Control	38	79.255	4.515	0.709	74	0.481
Experimental	38	78.395	5.971			

The result of the t-test for the comparison between the two group was 0.709. This comparison resulted in the P value of 0.481. This value was greater than 0.05, therefore, there was no significant difference between the mean scores of $PRE_{Exp.}$ (experimental averages) and $PRE_{Cnt.}$ (control averages) and therefore, null hypothesis I was not rejected. Therefore, initially there was no significant difference between the control and the experimental groups.

Hypothesis II

There will be no significant difference between the mean scores of $\mu_{E\,Q1} \cdots \mu_{E\,Q12}$ (experimental averages) and $\mu_{C\,Q1} \cdots \mu_{C\,Q12}$ (control averages).

Ho: $\mu_{E\,Q1} \cdots \mu_{E\,Q12} = \mu_{C\,Q1} \cdots \mu_{C\,Q12}$

Ha: $\mu_{E\,Q1} \cdots \mu_{E\,Q12} \neq \mu_{C\,Q1} \cdots \mu_{C\,Q12}$

A repeated measures analysis of variance revealed a statistically significant main effect for the groups variable $F(1,72)=11.246$, $P=0.001$, $\alpha=0.05$. Univariate F test comparisons revealed statistical significance at the first, fifth, sixth, and eleventh levels of the quiz variable. The null hypothesis was not accepted. Table 10-13 contains the standard error (SE) and adjusted least squares means (adjusted for the covariate) of quiz 1-12.

Table 10. Adjusted mean of quiz 1-6 (control group)

	Quiz 1	Quiz 2	Quiz 3	Quiz 4	Quiz 5	Quiz 6
Adjusted. LS Mean	17.684	17.890	18.904	15.123	16.528	16.454
Standard Error	0.321	0.246	0.272	0.339	0.334	0.358

Table 11. Adjusted mean of quiz 1-6 (experimental group)

	Quiz 1	Quiz 2	Quiz 3	Quiz 4	Quiz 5	Quiz 6
Adjusted. LS Mean	16.737	17.379	18.385	14.009	15.328	14.932
Standard Error	0.321	0.246	0.272	0.399	0.334	0.358

Table 12. Adjusted mean of quiz 7-12 (control group)

	Quiz 7	Quiz 8	Quiz 9	Quiz 10	Quiz 11	Quiz 12
Adjusted. LS Mean	16.211	15.910	15.244	17.367	15.252	15.639
Standard Error	0.355	0.366	0.486	0.403	0.414	0.425

Table 13. Adjusted mean of quiz 7-12 (experimental group)

	Quiz 7	Quiz 8	Quiz 9	Quiz 10	Quiz 11	Quiz 12
Adjusted. LS Mean	15.965	15.466	14.726	16.502	13.768	14.591
Standard Error	0.355	0.366	0.486	0.403	0.414	0.425

Table 14 contains the summary of the multivariate repeated measures analysis of variance between groups. The effects of attendance and pretest have been controlled for by using an analysis of covariance. Table 15 shows the within subject interaction. In this table all the probabilities are greater than α=0.05. Table 16 contains the univariate F tests for quizzes 1-12. As shown in Table 16, the P value at α=0.05 is significant for the first, fifth, sixth, and eleventh quiz. The mean in all four quizzes were in favor of the control group.

Table 14. Between subjects multivariate analysis of variance for quiz 1-12

Source	SS	DF	MS	F	P
Group	158.153	1	158.153	11.246	0.001*
Error	1012.599	72	14.063		

* Significant at α=0.05

Table 15. Within subjects multivariate analysis of variance for quiz 1-12

Source	SS	DF	MS	F	P
Quiz	53.008	11	4.819	1.1153	0.316
Quiz*Group	34.204	11	3.109	0.744	0.696
Quiz*Attendance	49.435	11	4.494	1.076	0.378
Quiz*Pretest	58.525	11	5.320	1.273	0.253
Error	3308.855	792	4.178		

Table 16. Univariate F test for quiz 1-12

Source	SS	DF	MS	F	P
Quiz 1	15.679	1	15.679	4.165	0.045 *
Error	271.010	72	3.764		
Quiz 2	4.569	1	4.569	2.066	0.155
Error	159.264	72	2.212		
Quiz 3	4.713	1	4.417	1.755	0.189
Error	193.316	72	2.685		
Quiz 4	21.701	1	21.701	3.750	0.057
Error	416.640	72	5.787		
Quiz 5	25.188	1	25.188	6.194	0.015 *
Error	292.815	72	4.067		
Quiz 6	40.523	1	40.523	8.668	0.004 *
Error	336.595	72	4.675		
Quiz 7	1.053	1	1.053	0.229	0.634
Error	331.033	72	4.598		
Quiz 8	3.449	1	3.449	0.706	0.403
Error	351.564	72	4.883		
Quiz 9	4.687	1	4.687	0.545	0.463
Error	619.172	72	8.600		
Quiz 10	13.092	1	13.092	2.219	0.141
Error	424.851	72	5.901		
Quiz 11	38.516	1	38.516	6.156	0.015 *
Error	450.447	72	6.256		
Quiz 12	19.187	1	19.187	2.910	0.092
Error	474.708	72	6.593		

* Significant at $\alpha=0.05$

Hypothesis III

There will be no significant difference between the mean scores of $\mu_{E\,H1} \cdots \mu_{E\,H12}$ (experimental averages) and $\mu_{C\,H1} \cdots \mu_{C\,H12}$ (control averages).

Ho: $\mu_{E\,H1} \cdots \mu_{E\,H12} = \mu_{C\,H1} \cdots \mu_{C\,H12}$

Ha: $\mu_{E\,H1} \cdots \mu_{E\,H12} \neq \mu_{C\,H1} \cdots \mu_{C\,H12}$

A repeated measures analysis of variance revealed no statistical significance for the homework variable, $F(1,72)=1.648$, $P=0.203$, $\alpha=0.05$. The null hypothesis was not rejected. A statistically significant interaction effect was found, however, between the pretest covariate and the second, third, and fourth homework assignments (between-group analysis of variance). Tables 17-20 contains the standard error (SE) and adjusted least squares means of homework assignments 1-12.

Table 21 contains the summary of the multivariate repeated measures analysis of variance between groups. The effects of attendance and pretest have been limited by using an analysis of covariance. Since $P=0.203>0.05=\alpha$ for the group effect, the univariate analysis of variance is not needed.

Table 17. Adjusted mean of homework (Control group)

	HW 1	HW 2	HW 3	HW 4	HW 5	HW 6
Adjusted. LS Mean	16.737	17.379	18.385	14.009	15.328	14.932
Standard Error	0.321	0.246	0.272	0.399	0.334	0.358

Table 18. Adjusted mean of homework (experimental group)

	HW 1	HW 2	HW 3	HW 4	HW 5	HW 6
Adjusted. LS Mean	29.886	31.381	30.278	24.789	27.438	27.459
Standard Error	0.452	0.392	0.594	0.578	0.724	0.579

Table 19. Adjusted mean of homework (control group)

	HW 7	HW 8	HW 9	HW 10	HW 11	HW12
Adjusted. LS Mean	30.100	28.638	28.796	27.656	39.391	27.421
Standard Error	0.493	0.607	0.661	0.626	0.575	0.712

Table 20. Adjusted mean of homework (experimental group)

	HW 7	HW 8	HW 9	HW 10	HW 11	HW 12
Adjusted. LS Mean	30.307	28.954	27.972	27.851	27.797	27.119
Standard Error	0.493	0.607	0.661	0.626	0.575	0.712

Table 22 shows the interaction within subjects. In this table all the probabilities are greater than α=0.05. It also should be noted that interactions among the students was possible due to the fact that some students worked in group(s).

Table 21. Between subjects multivariate analysis of variance for homework 1-12

Source	SS	DF	MS	F	P
Group	101.178	1	101.718	1.648	0.203
Error	4443.549	72	61.716		

Table 22. Within subjects multivariate analysis of variance for homework 1-12

Source	SS	DF	MS	F	P
Quiz	103.848	11	9.441	1.147	0.321
Quiz*Group	120.754	11	10.987	1.334	0.200
Quiz*Attendance	87.208	11	7.928	0.964	0.467
Quiz*Pretest	107.757	11	9.796	1.191	0.299
Error	6515.994	792	8.227		

Hypothesis IV

There is no significant difference between the mean scores of $\mu_{E\ MID}$, (experimental averages) and $\mu_{C\ MID}$, (control averages).

Ho: $\mu_{E\ MID} = \mu_{C\ MID}$

Ha: $\mu_{E\ MID} \neq \mu_{C\ MID}$

A two-way repeated measures analysis of variance conducted for the midterm and the final examinations revealed no statistically significant results between the groups, $F(1,72)=2.739$, $P=.102$, $\alpha=0.05$. Table 23 contains the standard error (SE) and adjusted least squares means for the midterm and final variables. Table 24 contains the summary table of the multivariate

Table 23. Between subjects multivariate analysis of variance for midterm and final

Source	SS	DF	MS	F	P
Group	206.000	1	206.000	2.739	0.102
Error	5415.437	72	75.214		

Table 24. Adjusted mean of midterm and final

	Control		Experimental	
	Midterm	Final	Midterm	Final
Adjusted Mean	87.919	76.139	85.427	73.776
Standard Error	0.927	1.484	0.927	1.484

repeated measures analysis of variance between groups. The effects of attendance and pretest have been controlled by using an analysis of covariance. No statistical significant was found.

Table 25 shows the interactions within subjects. It should be noted that interactions among the students were not possible since the midterm test was administered by the instructor, this was also true for the quizzes. The interaction between the midterm and final was possible since the two examinations had some items in common.

Table 25. Within subjects multivariate analysis of variance for midterm and final

Source	SS	DF	MS	F	P
(Midterm & Final)	283.813	1	283.813	7.818	0.007*
(Midterm & Final)*Group	0.147	1	0.147	0.004	0.949
(Midterm & Final)*Attendance	751.638	1	751.638	20.704	0.000*
(Midterm & Final)*Pretest	4.456	1	4.456	0.123	0.727
Error	2613.860	72	36.304		

* Significant at α=0.05

Hypothesis V

There is no significant difference between the mean scores of $\mu_{E\ FIN}$, (experimental averages) and $\mu_{C\ FIN}$, (control averages).

Ho: $\mu_{E\ FIN} = \mu_{C\ FIN}$

Ha: $\mu_{E\ FIN} \neq \mu_{C\ FIN}$

A two-way repeated measures analysis of variance was conducted for the midterm and final examinations variables revealed no statistically significant results between the groups, $F(1,72)=2.739$, $P=0.102$, $\alpha=0.05$. Table 24 contains the summary table of the multivariate repeated measures analysis of variance between groups. The effect of attendance and the pretest have been controlled by using an analysis of covariance. No statistical significant difference was found. Table 25 shows the interaction within subjects. It should be noted that interactions among the students were not possible since the final test was administered by the instructor. The interaction between the midterm and final was possible since they had some item questions in common.

<u>Hypothesis VI</u>

There is no significant difference between the mean scores of $\mu_{E\ DIF}$, (experimental averages) and $\mu_{C\ DIF}$, (control averages).

Ho: $\mu_{E\ DIF} = \mu_{C\ DIF}$

Ha: $\mu_{E\ DIF} \neq \mu_{C\ DIF}$

A t-test for the comparison between the two groups regarding the number of difficult items in quizzes, midterm, and final examination (t, df, = -0.945) revealed no statistically significant differences (item difficulties at level of 65%[1]). The results of the t-test are shown in Table 26.

Table 26. The t-test between the difficult items of control and experimental group

Group	N	Mean	SD	T	DF	P
Control	27	9.519	9.120	-0.945	52	0.349
Experimental	27	11.852	9.029			

The pretest mean of the control group was 9.519, while the mean for the experimental group was 11.852. The standard deviation for the control group was 9.120, whereas, the mean for the experimental group was 9.029. This comparison resulted in the P value equal to 0.349 indicating that there is no

[1] A level of 100% occurs when all students answer a test/quiz item correctly.

significant difference between the mean scores of $\mu_{E\ DIF.}$ (experimental averages) and $\mu_{C\ DIF.}$ (control averages). Therefore, the null hypothesis was not rejected.

Hypothesis VII

There is no significant difference between the students' attendances of the experimental and the control group.

Ho: $\mu_{E\ ATT.} = \mu_{C\ ATT.}$

Ha: $\mu_{E\ ATT.} \neq \mu_{C\ ATT.}$

A t-test for the comparison between the two groups regarding student attendance revealed a statistically significant difference between the two groups. The results of the t-test are shown in Table 27.

Table 27. The t-test between the attendance of control and experimental group

Group	N	Mean	SD	T	DF	P
Control	38	14.487	0.934	2.486	74	0.015*
Experimental	38	13.579	2.048			

* Significant at α=0.05

The pretest mean of the control group was 14.487, while the mean for the experimental group was 13.579. The standard deviation for the control group was 0.934, while the mean for the experimental group was 2.048. The results of the t-test for the comparison between the two groups was 2.486. This comparison resulted in the P value of 0.015 and this value was less than

0.05, therefore, the null hypothesis was rejected. Since the mean score of control group was greater, students in the control group were attending more frequently than the experimental group.

Summary

This chapter reviewed the inferential statistics which included testing the seven hypotheses stated in chapter III. This section reviews the results of hypothesis testing in a summary form.

In null hypothesis I, the result the of t-test was not significant at α=0.05 concluding that significant differences between the background of the two groups did not exist.

In null hypothesis II, the results of a 2X12 repeated measures ANOVA was significant at α=0.05. The results of the univariate F test was significant for the first (Ohm's law and power), fifth (alternating current and voltages), sixth (capacitors), eleventh (frequency response of *RLC* circuits) quizzes. The adjusted mean was greater for the control group.

In null hypothesis III, the results of a 2X12 repeated measures ANOVA (homework) was not significant at α=0.05, therefore, the univariate F test was not used.

In null hypothesis IV, the results of a 2X2 repeated measures ANOVA (midterm) was not significant at α=0.05, therefore, the univariate F test was not used.

In null hypothesis IV, the results of a 2X2 repeated measures ANOVA (midterm) was not significant at α=0.05, therefore, the univariate F test was not used.

In null hypothesis V, the results of a 2X2 repeated measures ANOVA (final) was not significant at α=0.05, therefore, the univariate F test was not used.

In null hypothesis VI, the result of the t-test was not significant at α=0.05, therefore, the author concluded there were no significant differences among the difficult items as a result of the overall test items between the control group and the experimental group. The level of difficult items was set at 65% (A level of 100% occurs when all students answer an item correctly).

In null hypothesis VII, the result of t-test was significant at α=0.05 concluding that students in the control group were attending the laboratory more frequently than the experimental group.

CHAPTER V. SUMMARY, DISCUSSION, AND RECOMMENDATIONS

This chapter will discuss the overview, need, justification and the author's interpretation about the outcomes of this study. At the end of this chapter recommendations are given for further research studies of the effectiveness of computer simulation.

Summary

This study was designed to compare the achievement of college students who learned electronics concepts by computer simulation versus those who learned by traditional laboratory instruction. This study took one academic year for its completion. During this nine-month period, two groups of college students enrolled in a basic electronics course (A.C. and D.C. currents) participated in this study.

The first group (January - May, 1992) was the control group. The students in this group received traditional laboratory instruction which involved working with the actual components (passive devices). The second group (August - December, 1992) was the experimental group. In addition to traditional laboratory instruction which involved working with the actual components (passive devices), the students in this group received computer simulation instructions. Twelve topics were covered in both groups. The following measurements were made:

1. three pretests;

2. twelve quizzes and twelve homework assignments;
3. a midterm exam;
4. a final exam;
5. attendance of students who took part in the study;

The subjects of this study were students enrolled in a IEDT 140 beginning electronics course at the Department of Industrial Education and Technology, Iowa State University.

The review of literature covered in Chapter II contains numerous studies in favor of applying computer simulation in schools. Based on these previous studies, the author hypothesized that the usage of computer simulation would enhance the learning process for college students majoring in industrial technology. Although there were some studies which did not find any significant difference in favor of computer simulation, these studies did not provide a solid answer as to whether or not computer simulation should be applied in basic electronics courses taught in technology schools.

In summary, this research study was undertaken to determine whether computer simulation should be used as a compliment for enhancing learning in technology related areas.

Findings

After analyzing the data gathered from the pretest, quizzes, homework assignments, students' attendance, difficult items (quizzes, midterm and final) midterm and final examination, the following results were found:

1. No significant difference was found for the results of pretests between the control and the experimental groups. The results of the t-test did not reveal significant at value differences $\alpha=0.05$; therefore, null hypothesis I was accepted.
2. A significant difference was found at $\alpha=0.05$ for the results of the ANOVA for the quizzes; therefore, null hypothesis II was rejected. Significant differences were found at the first (Ohm's law and power), fifth (alternating current and voltages), sixth (capacitors) and eleventh (frequency response of *RLC* circuits) quizzes. The results were in favor of the control group for the above four.
3. No significant difference was found for the results of the ANOVA at $\alpha=0.05$ for the homework assignments; therefore, null hypothesis III was accepted. An interaction among the students was also found.
4. No significant difference was found at $\alpha=0.05$ for the results of the ANOVA for the midterm examination; therefore, null hypothesis IV was not rejected.
5. No significant difference was found at $\alpha=0.05$ for the results of the ANOVA for the final examination; therefore, null hypothesis V was not rejected.
6. No significant difference was found for the results of the difficult items on the quizzes and tests between the control and experimental groups. The

result of the t-test was not significant at $\alpha=0.05$; therefore, null hypothesis VI was accepted. The results of hypothesis VI differ from two earlier studies by Miller (1986) and Zmurko (1990) who concluded that simulation enhances the learning process in more complex topics.

7. A significant difference was found for the result of the difficult items in the students' laboratory attendance between the control and the experimental groups. The results of a t-test were significant at $\alpha=0.05$; therefore, null hypothesis VII was rejected. The results were in favor of the experimental group.

Discussion

The overall outcome of this study suggested that students who used computer simulation as a tool for enhancing achievement in IEDT 140 (basic electronics) performed similarly, and in some cases worse than students who had not receive computer simulation.

Observations

During this study some additional observations were made by the researcher:

1. The participanting students in this study were more concerned about their grade than learning the materials. This observation was more evident for the experimental group.
2. The majority of students in the experimental group were not familiar with

usage of Windows software.

3. Some students in the experimental group were not familiar with any type of computer nor could they use floppy diskettes.
4. The degree of frustration was significantly higher for the experimental group during the entire semester.
5. Students in the control group tended to ask more questions about the quiz items after it was taken.
6. Some students in the experimental group were more positive about the computer simulation software used in this study (PSpice) after moving to advanced electronics courses.
7. The students in the control group turned in their in-class assignments more regularly than did the experimental group.
8. The students in the control group spent more time using calculators whereas the students in the experimental group spent more time using the computer. This factor, perhaps, helped the students in the control group to perform better in some quizzes. They were more experienced and familiar with the use of calculators.

Limitations

Several limiting factors were involved in this study:

1. This study was a quasi-experimental design and random sampling was not possible. Intact classes were asked to serve as one of the two groups.

2. Undergraduate students participating in this study were predominantly transfer students from the College of Engineering due to their insufficient progress in that college or because of a career change decision.
3. Most of the undergraduate students participating in this study had a negative bias toward studying electronics as observed in student interactions with the instructor.
4. The software used in this study (PSpice) is an industrially used software and does not contain adequate information for beginners.
5. No reading materials were available for usage of the software other than the software manual which was too difficult for most students to interpret.
6. The experimental group in this study was not allowed to use the software for quizzes, midterm and final.
7. A majority of the participants in this study were students from the State of Iowa.

Recommendations

The approach outlined in this study should be replicated in other colleges and universities as well as in other technology related areas. The findings of this study, contrast with the results of some other studies. Eucker (1984), Dick (1985), Coyle (1985), and Thomas and Hooper (1991), indicated that using computer simulation would enhance the learning process.

This study should be replicated in areas where more complex topics are taught since computer simulation tends to be more effective in complex topics (Miller, 1986; Zmurko, 1990).

Hwang (1989) found that students who worked with a partner and received computer simulation scored similarly to those who received traditional instruction. The findings also indicated that students who received computer simulation asked fewer question about the laboratory instructions.

After this study was concluded, the author had an opportunity to work with the students in the experimental group in a higher level electronics course and observed that these students had enhanced their achievements by using computer simulation (in this case PSpice was also used).

The following recommendations are beneficial to any further research about the effectiveness of computer simulation in schools. There is a need to conduct research studies using:

1. tools of measurement other than the multiple-choice question approach, perhaps a hands-on type of test with limited time.
2. a greater sample size and a larger number of participants.
3. computer simulation software other than PSpice, perhaps an educational software.
4. participants who have more diversity and computer literacy in their background.
5. participants who have more freedom over their participation. Even

though the participation in this research was voluntary, the course was required for a majority of the students.

6. a random sample.
7. topics involving more complicated circuitry such as digital and microprocessor related areas.
8. computers other than the IBM platform, such as Apple computers.

REFERENCES

Accelerator lets PC run circuit-simulation software at mainframe speed. (1985, July, 25). EDN, pp. 152.

Agnew, J. (1991, November 7). Simulating audio transducers with Spice. Electronic Design, pp. 45-57.

Ahmad, M., & Rassy, E. (1990, April). Thermal analysis with PSpice. IEE Communications Magazine, pp. 95-97.

Banzhaf, W. (1991). Using SPICE for circuit analysis. Electrosoft, 2, 21-34.

Baureis, P., McKinley, W., & Seitzer, D. (1991). A new large signal model for heterojunction bipolar transistors including temperature effects. Proceedings of the Custom Integrated Circuits Conference, 4.

Berube, R. H. (1993). Electronic devices and circuits using Micro-Cap III. New York: Merrill.

Blackwell, S. R. (1991, March 14). Frequency divider is programmable. Electronic Design, pp. 86-87.

Borst, R. A. (1985). A validation and reliability study of a computer simulation designed to test for control of variables (Doctoral dissertation, Georgia State University, 1985). Dissertation Abstracts International, 46, 12A.

Butler, R. H. (1991). Cooperative learning and computer simulations: Examining effects on the problem-solving abilities of sixth-grade students (Doctoral dissertation, Peabody College for Teachers of Vanderbilt University, 1991). Dissertation Abstracts International, 52, 03A.

Cannaday, Jr., K. (1990). A comparative study of the relative effectiveness of computer-assisted instruction, cooperative learning and teacher-directed instruction on improving math performance of low-achieving students (Doctoral dissertation, Virginia Polytechnic Institute and State University, 1990). Dissertation Abstracts International, 51, 04A.

Carlsen, D. D. (1989). Overcoming student preconceptions about simple series circuits: Promoting conceptual change with text manipulations and a microcomputer simulation (Doctoral dissertation, Iowa State University, 1989). Dissertation Abstracts International, 51, 01A.

Choi, B. (1984). The effectiveness of a simulated experiment using the attributes of the microcomputer on student understanding of the volume displacement concept in the junior high school (Doctoral dissertation, University of Minnesota, 1984). Dissertation Abstracts International, 45, 08A.

Chuang, C. P. (1990). Effectiveness of microcomputer aided television troubleshooting instruction using digital image database. (Doctoral dissertation, Iowa State University, 1990). Dissertation Abstracts International, 51, 11A.

Connell, E. W. (1991). An exploration of the determinants of attitude toward computers in middle school students (Doctoral dissertation, University of San Diego, 1991). Dissertation Abstracts International, 52, 06A.

Contant, T. L. (1987). Microcomputer simulations and the acquisition of motion physics concepts and integrated process skills (Doctoral dissertation, University of Houston, 1987). Dissertation Abstracts International, 47, 04A.

Coyle, K. P. (1985). The development and evaluation of an experiential computer simulation for animal science students (Doctoral dissertation, Iowa State University, 1985). Dissertation Abstracts International, 46, 12A.

Dick, C. T., (1985). A computer simulation model for planning state school finance programs in Ohio: A feasibility study (Doctoral dissertation, University of Cincinnati, 1985). Dissertation Abstracts International, 46, 07A.

Donlin, M. (1992, March). Simulator supports transmission line models and filter synthesis. Computer Design, pp. 124-125.

Eisenkraft, A. J. (1986). The effects of computer simulated experiments and traditional laboratory experiments on subsequent transfer tasks in a high school physics course (Doctoral dissertation, New York University, 1986). Dissertation Abstracts International, 47, 10A.

Eucker, T. R., (1984). System assignment of learning strategies in a computer simulation of an imaginary science (Doctoral dissertation, University of Southern California, 1984). Dissertation Abstracts International, 45, 10A.

Floyed, R. E., (1991). Electronics fundamentals: Circuit, devices, and applications. (2nd ed.). New York: Merril, and imprint of Macmillan Publishing Company.

Gabay, J. (1992, February). PC-based analog simulation. Computer Design, pp. 135-137.

Garren, W. S. (1990). An experimental evaluation of using computer-aided design simulations in teaching basic electronics at the college level (Doctoral dissertation, North Carolina State University, 1990). Dissertation Abstracts International, 51, 04A.

Gokhale, A. A. (1989). To investigate the effectiveness of computer simulation versus laboratory experience, and the sequencing of instruction, in teaching logic circuits (Doctoral dissertation, Iowa State University, 1989). Dissertation Abstracts International, 51, 01A.

Grehan, R. (1993, May). Testing the Pentium. Byte, pp. 96.

Hagerman, J. (1991, March 14). Model thermistor with Spice. Electronic Design, pp. 85.

Halfhill, T. R. (1993, May). Intel launches rocket in a socket. Byte, pp. 92-108.

Hess, F. S. (1987). Evaluation of watts in a home: A microcomputer program for sixth through ninth grade science students (Doctoral dissertation, Columbia University Teachers College, 1987). Dissertation Abstracts International, 47, 01A.

Hollingsworth, M. G. (1987). An experimental study of a computer health simulation in a special education setting: Analysis of strategy application and knowledge transfer (Doctoral dissertation, University of Oregon, 1987). Dissertation Abstracts International, 49, 07A.

Howell, D. C., (1978). Statistical methods for psychology. (2nd ed.). Boston: PWS-Kent.

Hurt, R. L. (1991). The effects of computer-assisted instruction on motivation and anxiety in first-year undergraduate accounting students (Doctoral dissertation, Clarement Graduate School, 1991). Dissertation Abstracts International, 52, 06A.

Hwang, Y. (1989). The effectiveness of computer simulation in training programmers for computer numerical control machining (Doctoral dissertation, Iowa State University, 1989). Dissertation Abstracts International, 50, 09A.

Jones, H., T. (1990, April, 26). PSpice model simulates temperature sensor. EDN, pp. 225.

Kasler D. (1992, April 22). Ames animation firm wins grant. Des Moines Register, p. 8.

Kasow, M. D. (1990). Using a computer simulation to integrate eighth-grade social studies and mathematics (Doctoral dissertation, Columbia University Teachers College, 1990). Dissertation Abstracts International, 51, 07A.

Kelley, W. L. (1986). Transferability of computer simulated troubleshooting skills to the actual equipment (Doctoral dissertation, The University of Arizona, 1986). Dissertation Abstracts International, 47, 04A.

Koch, J., K. (1990, April, 26). Fan controller minimizes audible noise. EDN, 225-226.

Konstadakellis, C., S, S. & Laopoulos, T. (1992). A fast, versatile, CMOS time-to-voltage converter. 6th Mediterranean Electrotechnical Conference, p. 282-285.

Kraft, L. A. (1991). Modeling Lightning Performance to Transmission System Using PSpice. IEEE Transactions on Power Systems, 6, 543-547.

Krishnamachari, S. (1988). The use of computer simulations in teaching probability (Doctoral dissertation, Columbia University Teachers College, 1988). Dissertation Abstracts International, 50, 01A.

Kronk, II, A. P. (1985). Computer assisted counselor training: A client simulation (Doctoral dissertation, The University of Michigan, 1985). Dissertation Abstracts International, 46, 05A.

Kruse, D. H. (1989). The effects of laboratory investigations using interactive videodisc or computer simulations on student control for variables, measurements, time involvement, interaction, success, and perceptions (Doctoral dissertation, 1989). Dissertation Abstracts International, 51, 02A.

Kun, D. (1990, April, 26). Program simplifiers Boolean expressions. EDN, pp. 238-242.

Larsen, M. V. T. (1986). The impact of selected variables on career stability (Doctoral dissertation, Rutgers the State University of New Jersey-New Brunskick, 1986). Dissertation Abstracts International, 48, 01A.

LaVoie, D. R. (1986). A qualitative analysis of the thought processes and related factors involved with the science process skill of prediction using an instructional computer simulation (Doctoral dissertation, The Florida State University, 1986). Dissertation Abstracts International, 47, 08A.

Looker D. (1992, August 6). Ethanol lobby pushes on Iowa corn growers has collected 17,000 names on a petition asking for approval of EPA. Des Moines Register, p. 10.

Lubert, S. (1986). Design of a novel educational instrument for use in physics courses with a formative evaluation in a secondary school setting (Doctoral dissertation, Columbia University Teachers College, 1986). Dissertation Abstracts International, 47, 06A.

Martin, J. P. (1989, October). PC breadboard, Electronics World and Wireless World, pp. 989-993.

McLellan, H. (1987). Microcomputers in a high school astronomy class: A case study (Doctoral dissertation, The University of Wisconsin-Madison, 1987). Dissertation Abstracts International, 48, 05A.

MicroSim Corporation. (1992). The design center: Circuit analysis-system setup manual, (Version 5.2), Irvine, CA: Author.

MicroSim Corporation. (1992). The design center: Circuit analysis-reference manual, (Version 5.2), Irvine, CA: Author.

MicroSim Corporation. (1992). The design center: Circuit analysis-user's guide, (Version 5.2), Irvine, CA: Author.

Miller, D. G. (1986). The integration of computer simulation into the community college (Doctoral dissertation, Florida Atlantic University, Dissertation Abstracts International, 47, 06A).

Milne, B. (1988, October 27). Updated circuit simulator handles mixed-mode design situations. Electronic Design, pp. 93-94.

Milner, A., & Wildberger, A.M. (1974). How should computers be used in learning. Journal of Computer-Based Instruction, 1(1), 7-12.

Mokhtari, H. Nyeck, A. Tosser-Roussey, C., & Tosser-Roussey, A. (1992). Finite difference method and Pspice simulation applied to the coaxial cable in a linear temperature gradient. IEE Proceedings-A, 139, 39-41.

Monssen, F. (1992). PSpice with circuit analysis. New York: Merrill.

Morad, A. A. & Beliveau, Y. J. (1991). Knowledge-Based Planing System. Journal of Construction Engineering and Management, 117, 1-12.

Morgan, T. D. (1987). The effect of utilizing a dynamic visual organizer to teach a computer sorting algorithm (Doctoral dissertation, University of Visrinia, 1987). Dissertation Abstracts International, 48, 12A.

Morgan, V. R. L. F. (1986). A comparison of an instructional strategy oriented toward mathematical computer simulations to the traditional teacher-directed instruction on measurement estimation (Doctoral dissertation, Boston University, 1986). Dissertation Abstracts International, 47, 02A.

Nehmadi, M. Ifrah, Y. Druckmann, I. (1990). Experimental result study and design enhancement of magnetic pulse compression circuit by using the PSPICE simulation program. Review of Scientific Instruments, 61, 3807-3811.

Nejad, M. A. (1992). A comparison and evaluation of the effectiveness of computer simulated laboratory instruction versus traditional laboratory instruction in solid state electronics circuitry. (Doctoral dissertation, Iowa State University, 1992). Dissertation Abstracts International, 93, 11522.

Oringer, R. H. (1986). Evaluation of planning for power, a preliminary study of a microcomputer program for seventh through ninth grade science students (Doctoral dissertation, Columbia University Teachers College, 1987). Dissertation Abstracts International, 47, 01A.

Park-Kim, K. Y. (1987). Current technology tools for K-12 public education (Doctoral dissertation, Columbia University Teachers College, 1987). Dissertation Abstracts International, 49, 01A.

Radice, R., M. (1991, March 1). Spice simulations use controlled sources to model NTSC signals. EDN, pp. 117-130.

Reesor, N. (1990, April, 26). Calculators convert numbers. EDN, pp. 242-245.

Rohrbach, N., & Stewat, B.R. (1986). Using microcomputer in teaching. The Journal of the American Association of Teacher Education in Agriculture, 27(4), 18-25.

Rosner, E. (1989). An evaluation of a computer assisted instructional unit in basic electrical awareness for sixth through ninth-grade science students (Doctoral dissertation, Columbia University Teachers College, 1989). Dissertation Abstracts International, 50, 03A.

Rowland, P. M. (1988). The effect of two modes of computer-assisted instruction and individual learning differences on the understanding of science concept relationships (Doctoral dissertation, New Mexico State University, 1988). Dissertation Abstracts International, 49, 04A.

Ryan, B. (1993, May). Inside the Pentium. Byte, pp. 102-104.

Schmid, J. L. (1989). Comparison of attitude toward computers in one computer and multi-computer secondary social science classrooms (Doctoral dissertation, University of Missouri-Saint Louis, 1989). Dissertation Abstracts International, 50, 12A.

Scott, J., B. (1989, January, 5). PSpice review reveals strengths, drawbacks of optional packages. EDN, pp. 193-198.

Sehi, G. H. (1990). The cost analysis of using interactive computer-simulated laboratory experiments in selected engineering technology courses (Doctoral dissertation, Southern Illinois University at Carbondale, 1990). Dissertation Abstracts International, 52, 05A.

Shaw, Jr., E. L., (1984). Effects of the use of microcomputer simulations on concept identification achievement and attitudes toward computers and science instruction of middle school students of various levels of logical reasoning ability (Doctoral dissertation, University of Georgia, (1984). Dissertation Abstracts International, 45, 09A.

Sherman, D. (1990, April, 26). Bender senses shocks. EDN, pp. 230-234.

Sorensen, P. R. (1984, March). Simulating reality with computer graphics. Byte, pp. 106-124.

Spearow, C. (1991, March 14). Increase DC-DC converter power. Electronic Design, pp. 86.

Stewart, P. (1992, January). Adding Spice to technology. Electronics World and Wireless World, pp. 33-37.

Taylor, W. G. (1984). A comparative study of the Aurora Higher Education Center shared facilities model and a plantran computer simulated model of the Auraria institutions in separate facilities (Doctoral dissertation, University of Denver, 1984). Dissertation Abstracts International, 45, 12A.

Thomas, R. & Hooper, E. (1991). Simulations: An opportunity we are missing. Journal of Research on Computing in Education, 23, 497-509.

Tuinenga, P. W. (1992). SPICE: A guide to circuit simulation & analysis using PSpice. MicroSim Corporation (2nd Ed.). Englewood Cliffs, Mew Jersey: Prentice-Hall.

Veit, S. (1993, March). What ever happened to IBM? Computers Shopper, pp. 772-773.

Vincent, B. G. (1991, April 11). Servo analysis gets a boost from parametric models. EDN, pp. 123-134.

Vincent, B. G. (1991, March 28). Electrical models of mechanical units widen simulator's scope. EDN, pp. 139-144.

Wen, B. R., & Triplett, J., D. (1991). Computer simulation of rail transit vehicle systems--Method and advantages. Proc 91 IEEE ASME Jt Railroad Conf Technical Papers - IEEE/ASME Joint. pp. 9-11.

Willis, D. A. S. (1989). Development and evaluation of IRIS: A computer simulation to teach preservice teachers to administer an informal reading inventory (Doctoral dissertation, Texas Tech University, 1989). Dissertation Abstracts International, 50, 06A.

Woodward, J. P. (1985). Teaching health concepts and problem solving skills through effective instructional practices and a computer simulation (Doctoral dissertation, University of Oregon, 1985). Dissertation Abstracts International, 46, 07A.

Ziegler, Jr., R. J. (1985). Assessment of the knowledge of preservice teachers regarding the quality of instructional computer simulations (Doctoral dissertation, 1985). Dissertation Abstracts International, 46, 10A.

Zmurko, J. H. (1990). Factors for staff development implementation of computer-assisted instruction by special education teachers in middle school (Doctoral dissertation, University of Maryland-College Park, 1990). Dissertation Abstracts International, 52, 02A.

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A very special thanks to my friends, Gary Schnellert, Rashid Bax, Anthony Stevens, and Ali Mehrabian for moral support and otherwise--friends like you are hard to find! Also, to Pat Hahn for her excellent editing, I am forever grateful.

Finally, I would like to express my thanks to Dr. Dugger, the Chairman of the Department of Industrial Education and Technology, who supported this research study.

APPENDIX A: HUMAN SUBJECTS COMMITTEE APPROVAL

Last Name of Principal Investigator Moslehpour

Checklist for Attachments and Time Schedule

The following are attached (please check):

12. [XX] Letter or written statement to subjects indicating clearly:
    a) purpose of the research
    b) the use of any identifier codes (names, #'s), how they will be used, and when they will be removed (see Item 17)
    c) an estimate of time needed for participation in the research and the place
    d) if applicable, location of the research activity
    e) how you will ensure confidentiality
    f) in a longitudinal study, note when and how you will contact subjects later
    g) participation is voluntary; nonparticipation will not affect evaluations of the subject

13. [ ] Consent form (if applicable)

14. [ ] Letter of approval for research from cooperating organizations or institutions (if applicable)

15. [ ] Data-gathering instruments

16. Anticipated dates for contact with subjects:

First Contact	Last Contact
8-24-92	12-14-92
Month / Day / Year	Month / Day / Year

17. If applicable: anticipated date that identifiers will be removed from completed survey instruments and/or audio or visual tapes will be erased:

____
Month / Day / Year

18. Signature of Departmental Executive Officer — Date — Department or Administrative Unit

John C. Clayman — 9/2/92 — I. Ed. T.

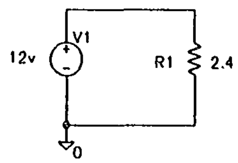
19. Decision of the University Human Subjects Review Committee:

X Project Approved ___ Project Not Approved ___ No Action Required

Patricia M. Keith — 9/24/92 — PM Keith
Name of Committee Chairperson — Date — Signature of Committee Chairperson

GC:1/90

APPENDIX B: COMPUTER SIMULATION LABORATORIES

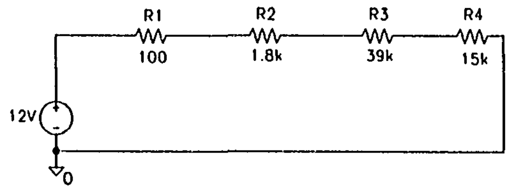


Iowa State University
Lab 1
IEDT 140

Page Size: A

Saeid Moslehpour

Revision: 1.0 Sept. 8, 1992 Page 1 of 1

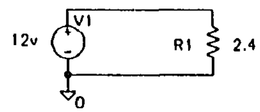


Iowa State University
Lab 2
IEDT 140

Page Size: A

Saeid Moslehpour

Revision: 1.0 Sept. 15, 1992 Page 1 of 1



Iowa State University
Lab 3
IEDT 140

Page Size: A

Saeid Mostehpour

Revision: 1.0 September 8 Page 1 of 1

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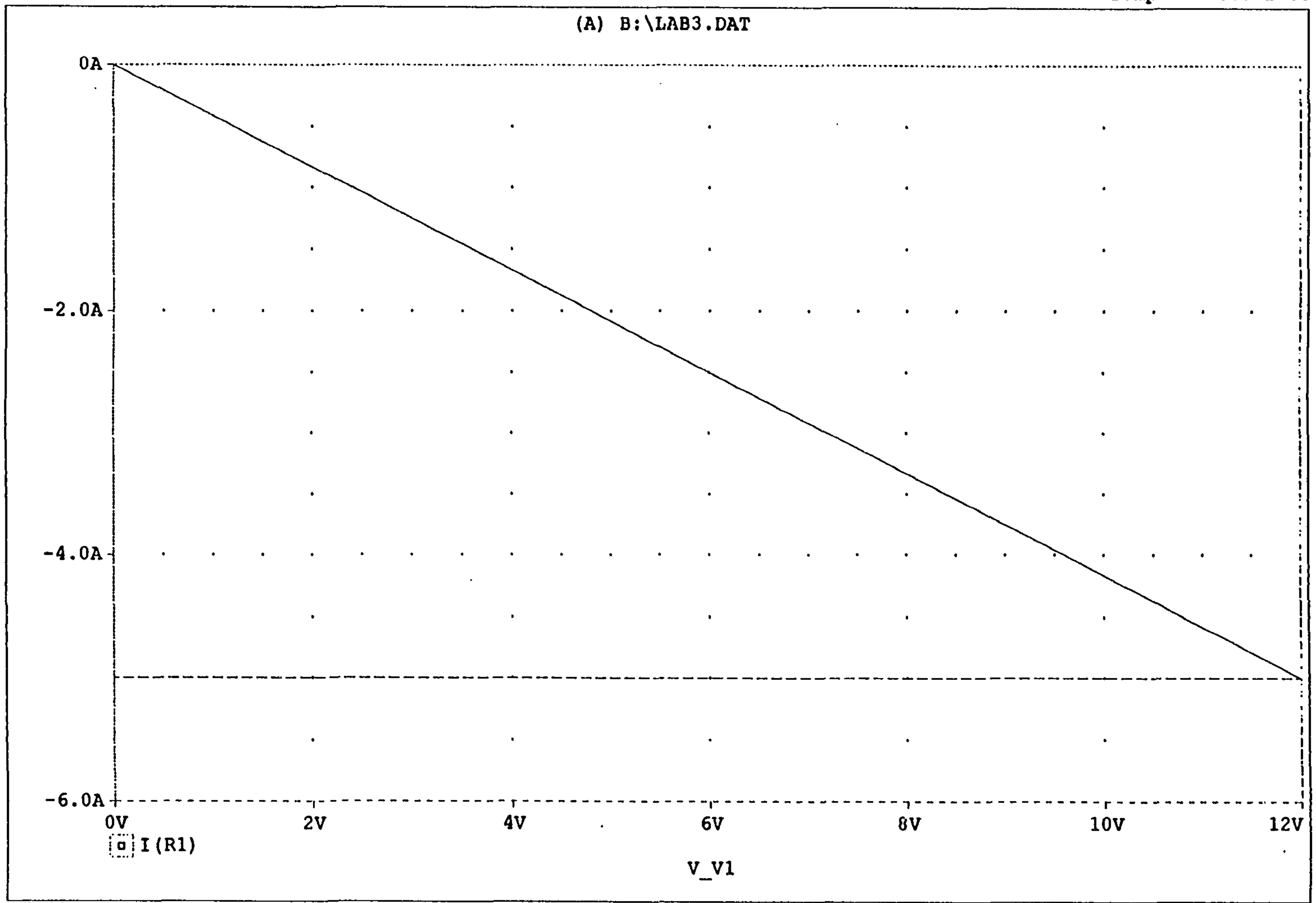

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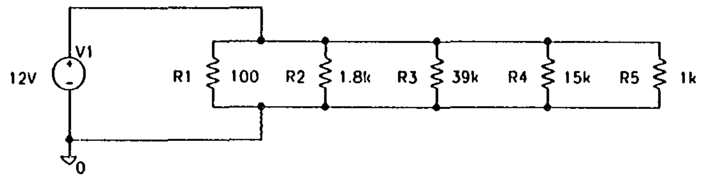

Iowa State University Lab 4 IEDT 140	Page Size: A
Saeid Moslehpour	
Revision: 1.1	Sept. 22, 1992 Page 1 of 1

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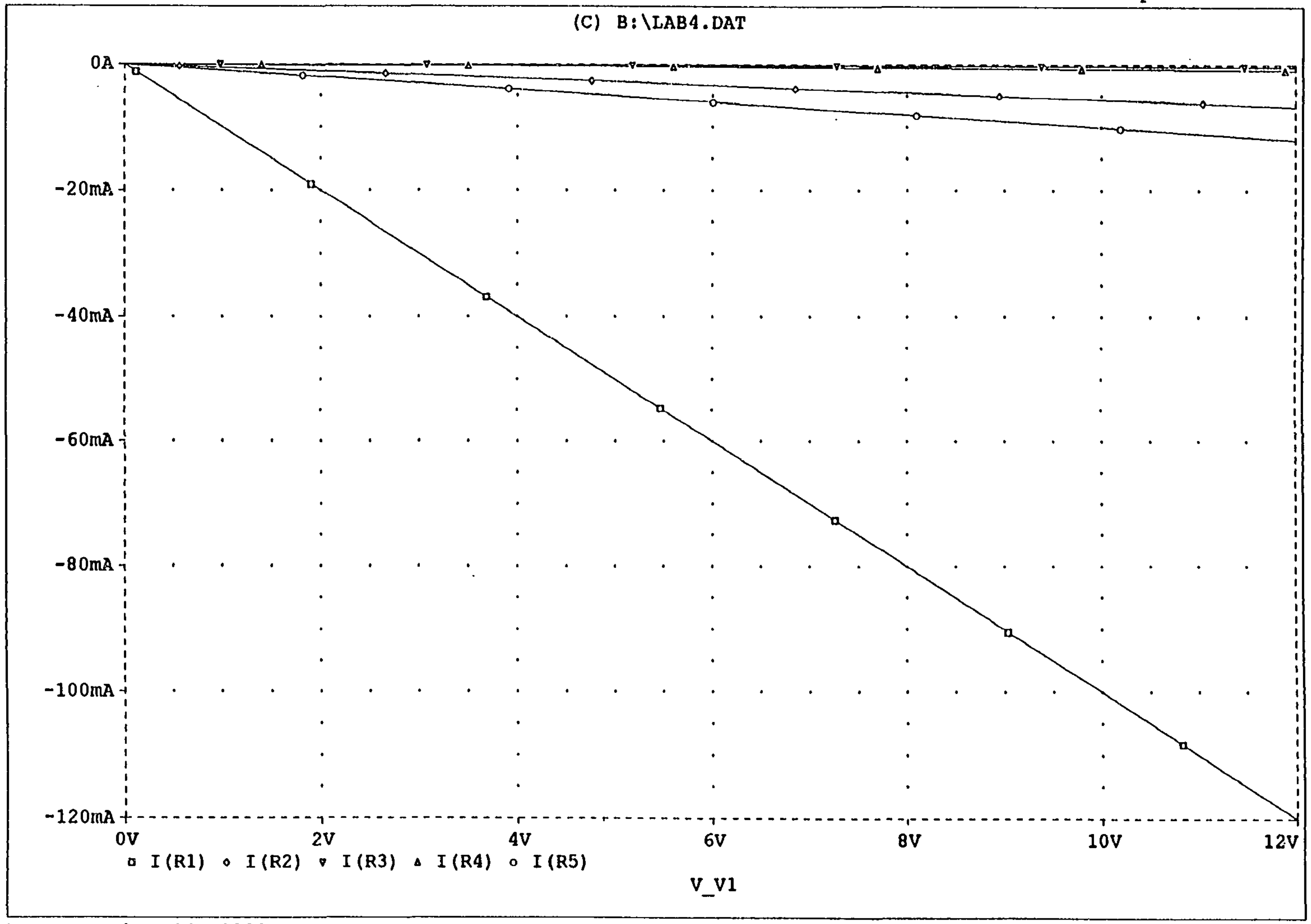

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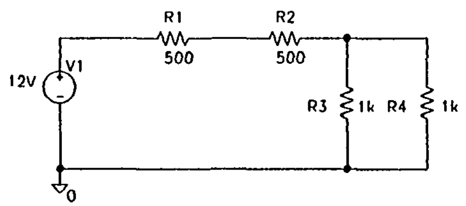

Iowa State University
Lab 5
IEDT 140

Page Size: A

Saeid Moslehpour

Revision: 1.1 | Oct. 1, 1992 | Page 1 of 1

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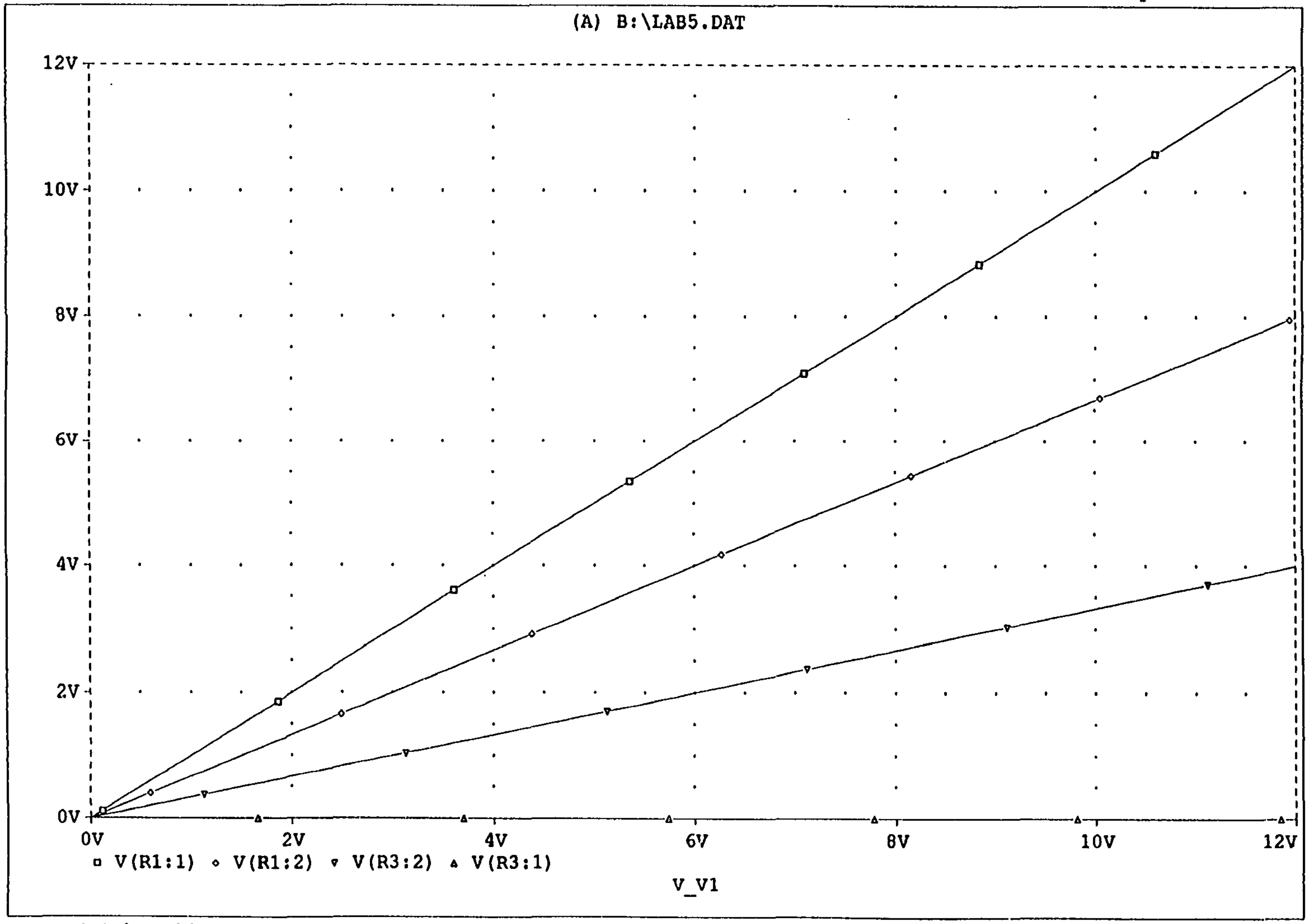

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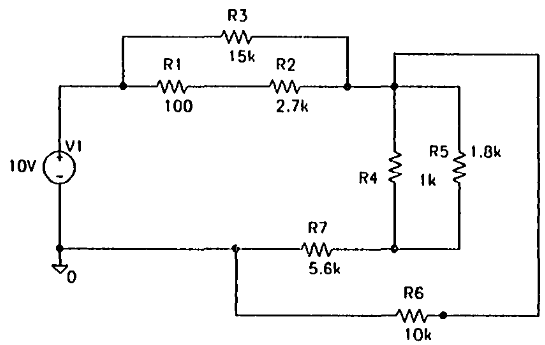

Iowa State University
Lab 5.2
IEDT 140

Page Size: A

Saeid Moslehpour

Revision: 1.2 Sept. 29,1992 Page 1 of 1

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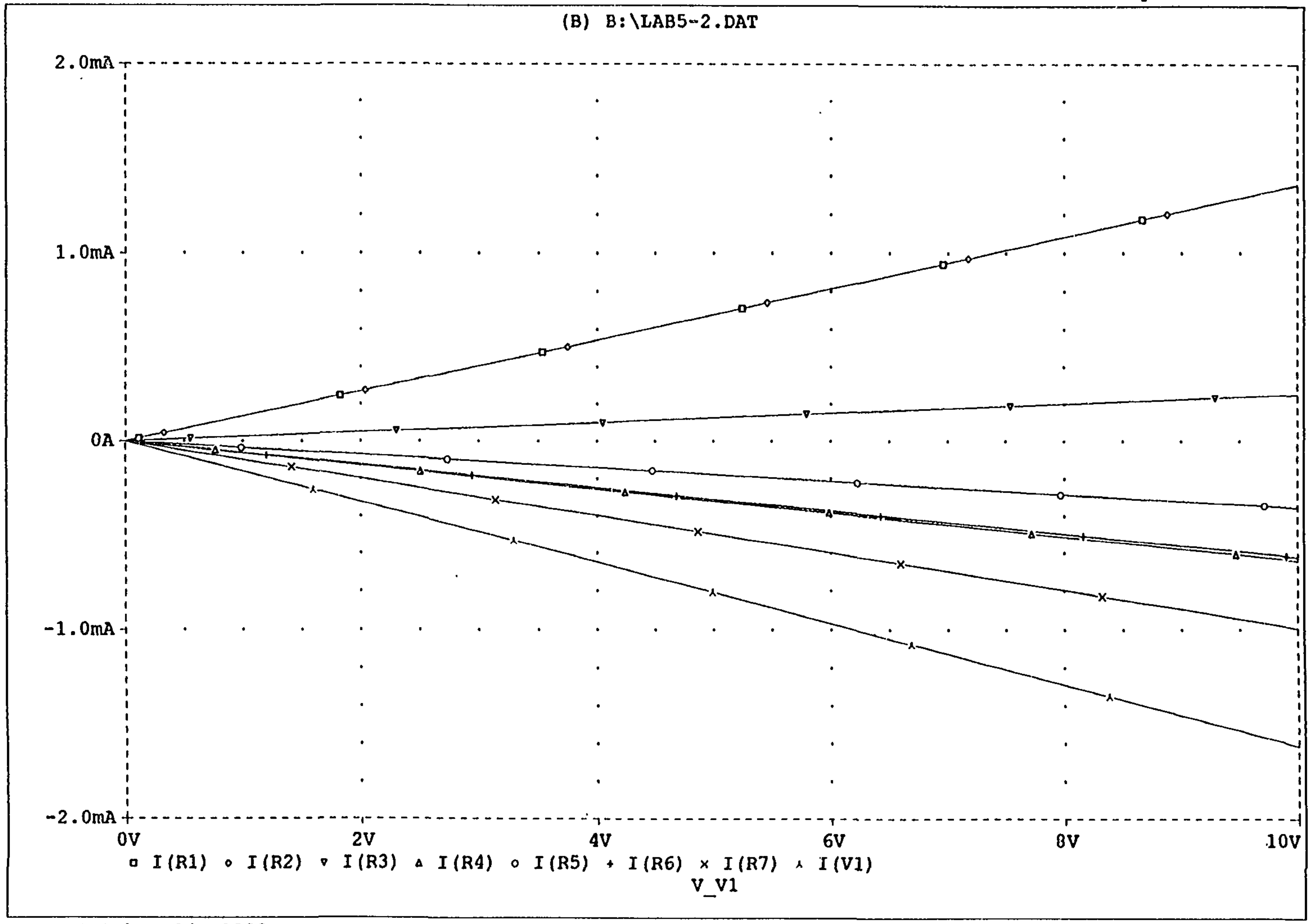

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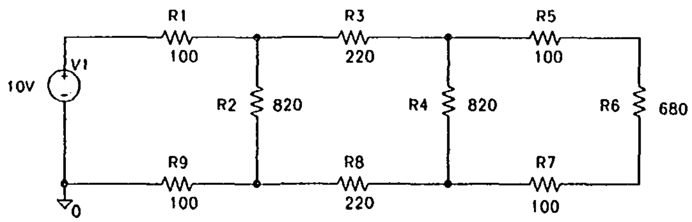

Iowa State University
Lab 6
IEDT 140

Page Size: A

Saeid Moslehpour

Revision: 1.4

Sept. 29, 1992 Page 1 of 1

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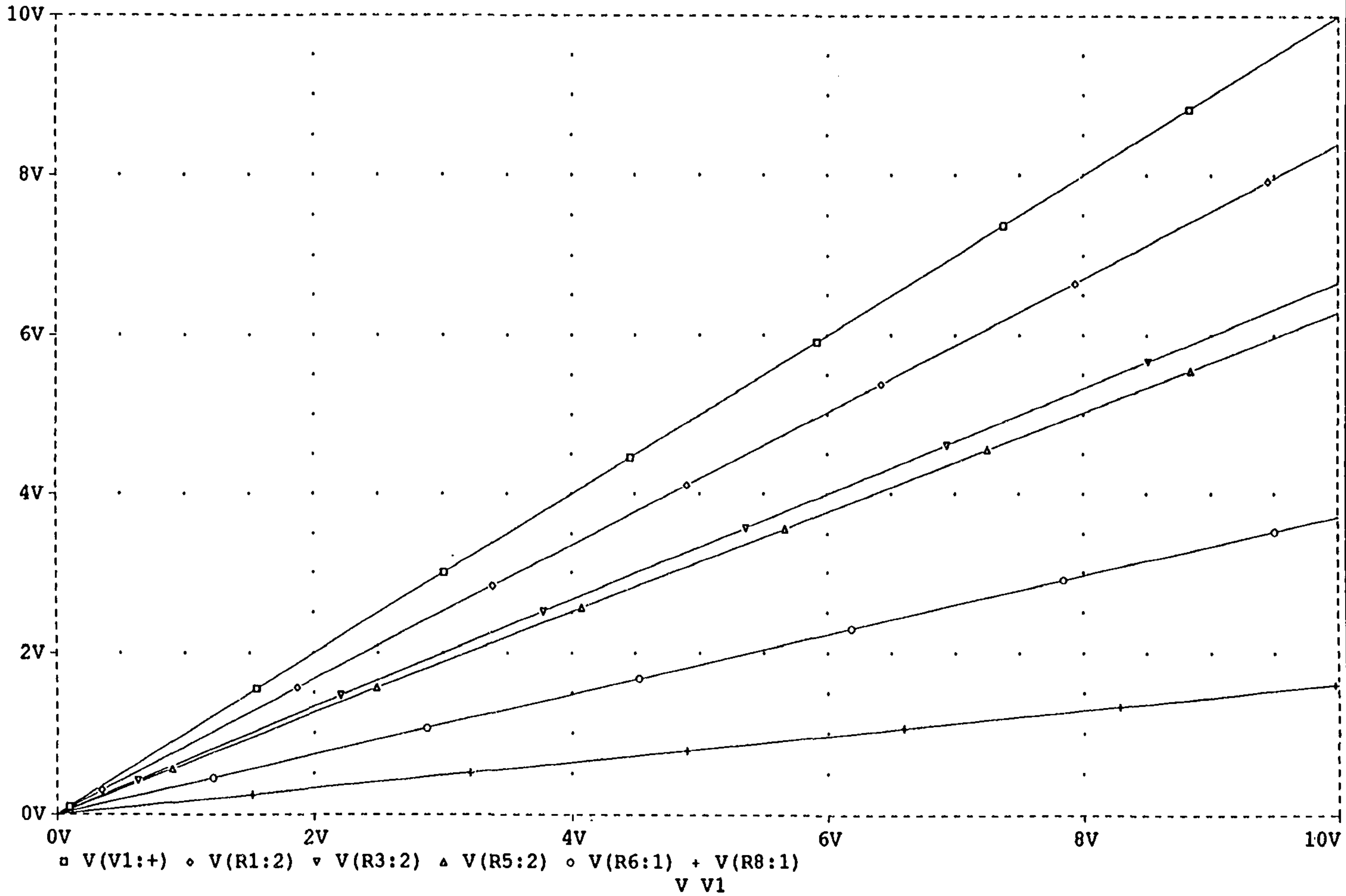

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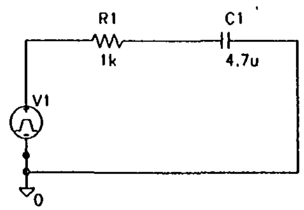

Iowa State University
Lab 7

Page Size: A

Saeid Moslehpour

Revision: 1.0 October 1992 Page 1 of 1

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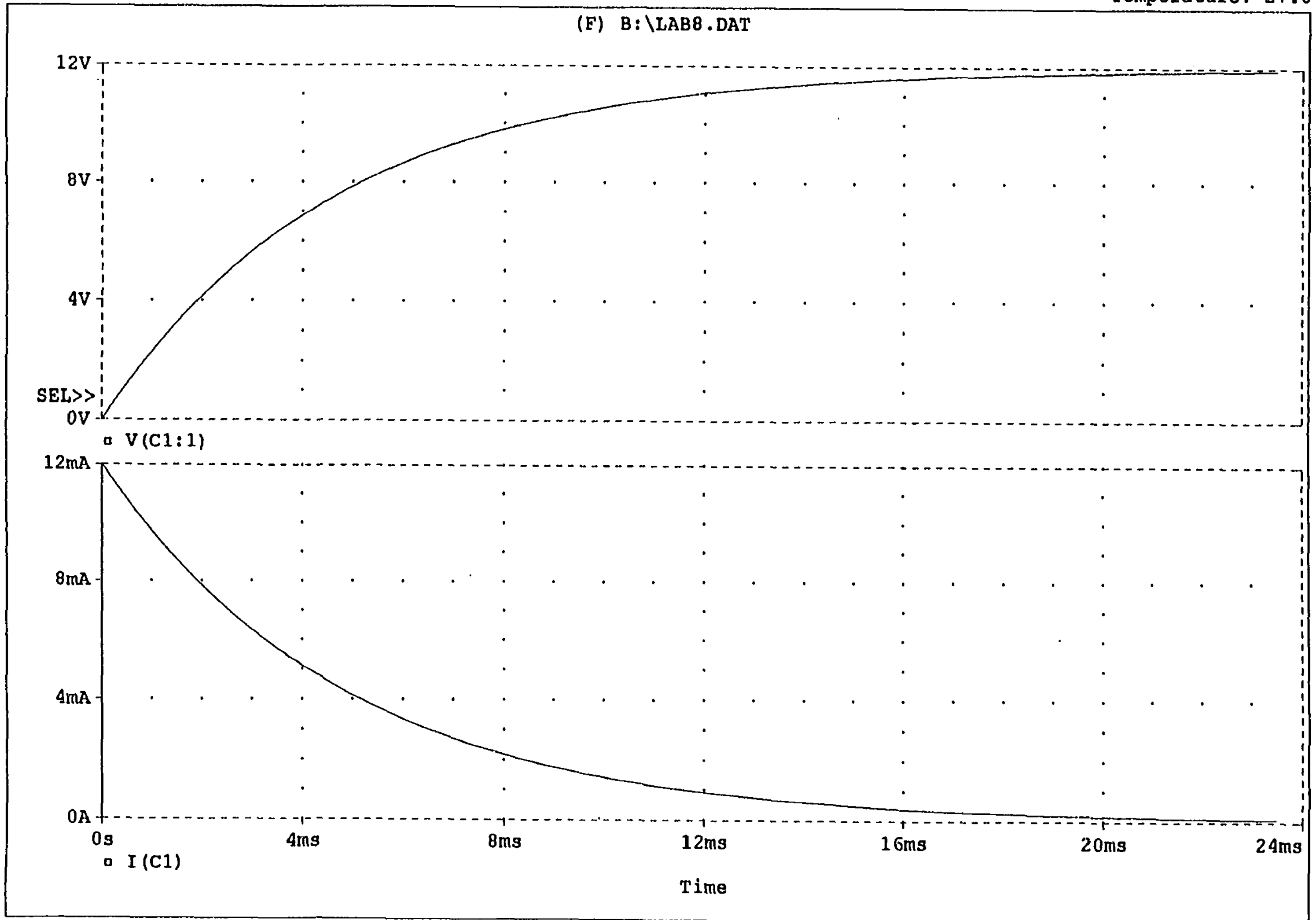

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Page 1

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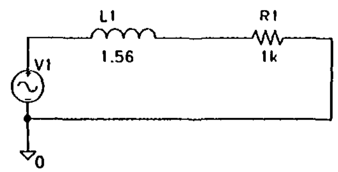

Iowa State University
Lab 8
IEDT 140

Page Size: A

Saeid Moslehpour

Revision: 1.0

October 1992 Page 1 of 1

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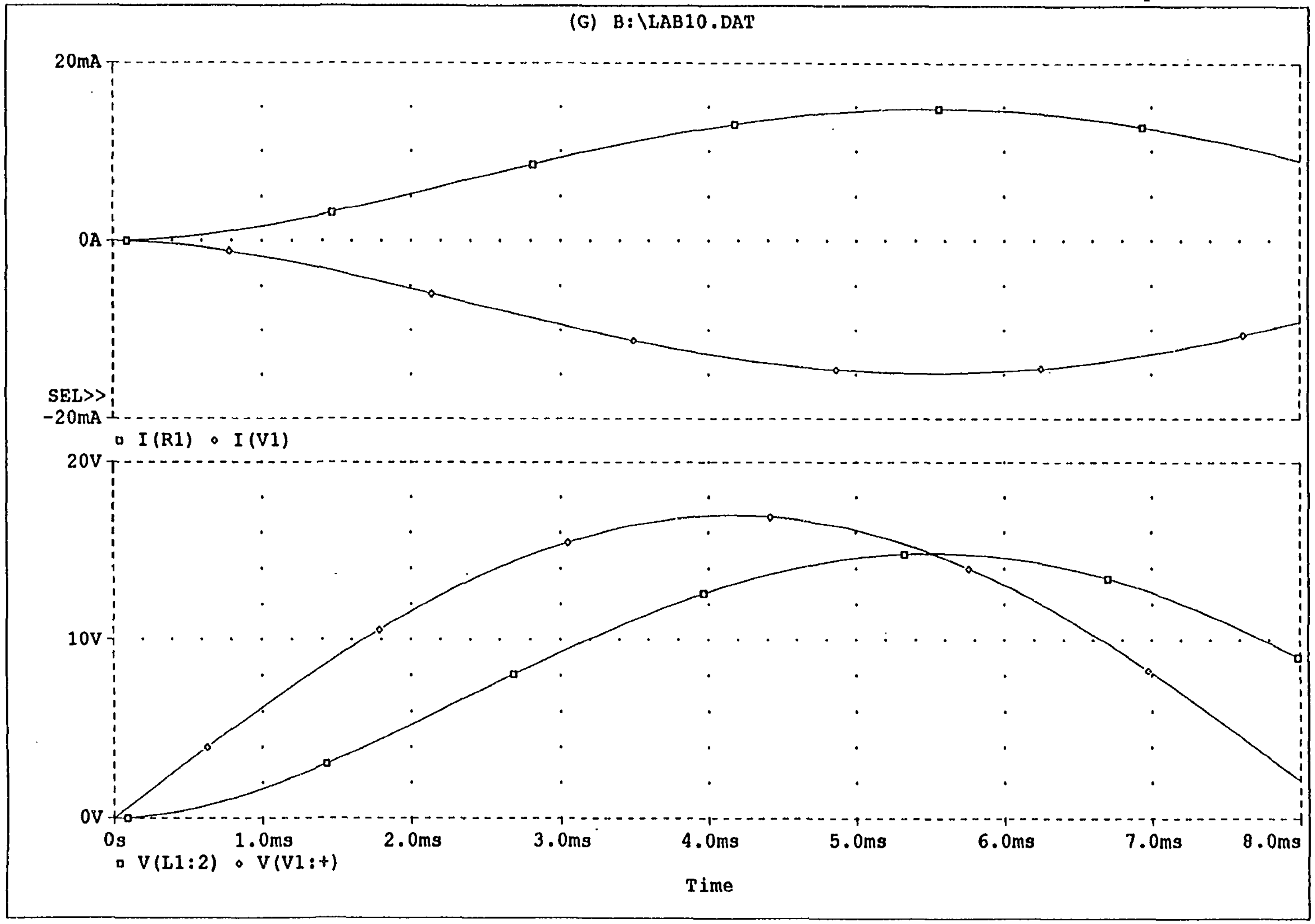

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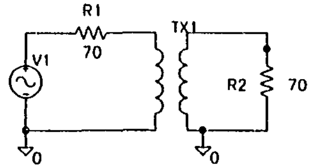

Iowa State University Lab9 IEDT 140	Page Size: A
Saeid Moslehpour	
Revision: 1.1 Nov. 3,1992	Page 1 of 1

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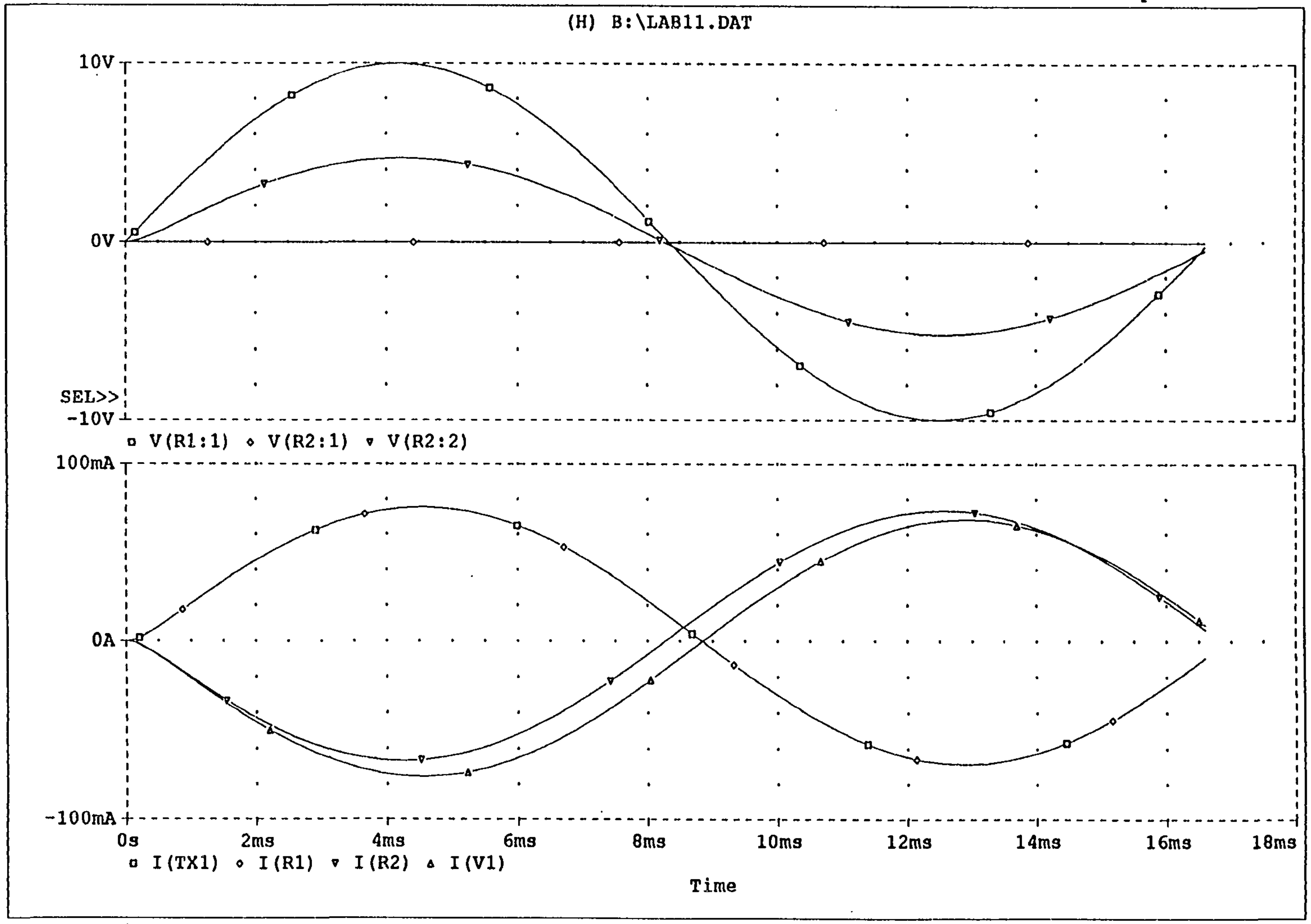

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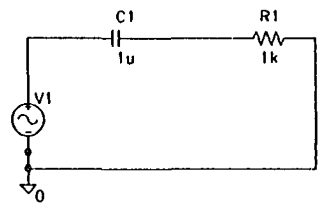

Iowa State University
Lab 9
IEDT 140

Page Size: A

Saeid Moslehpour

Revision: 1.0 Nov. 11,1992 Page 1 of 1

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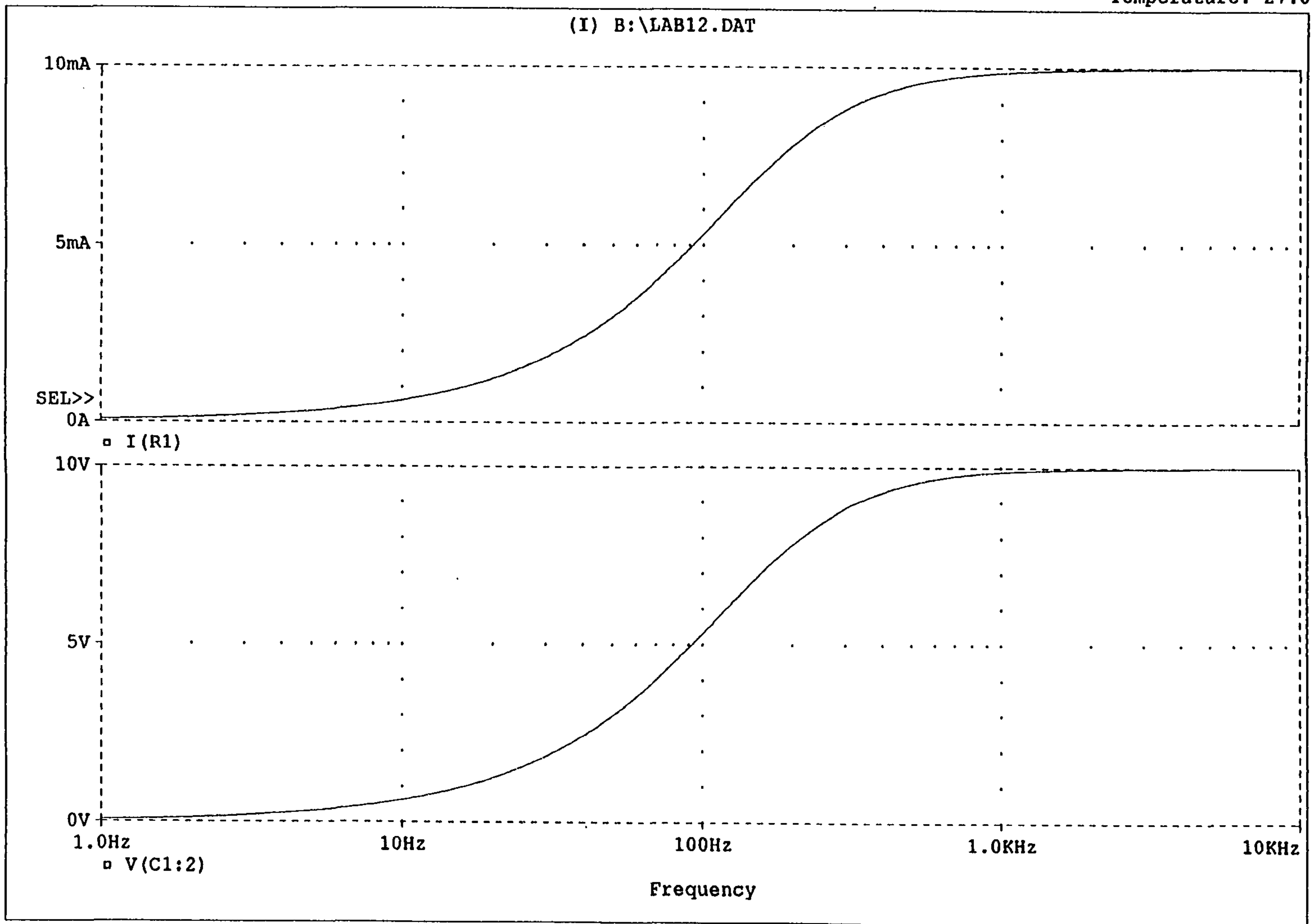

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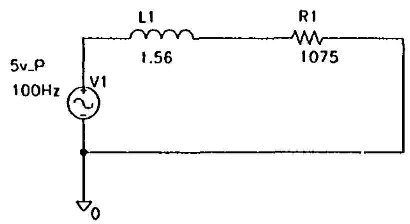

Iowa State University Lab 10 IEDT 140	Page Size: A
Saeid Moslehpour	
Revision: 1.0 November 18, 1999	Page 1 of 1

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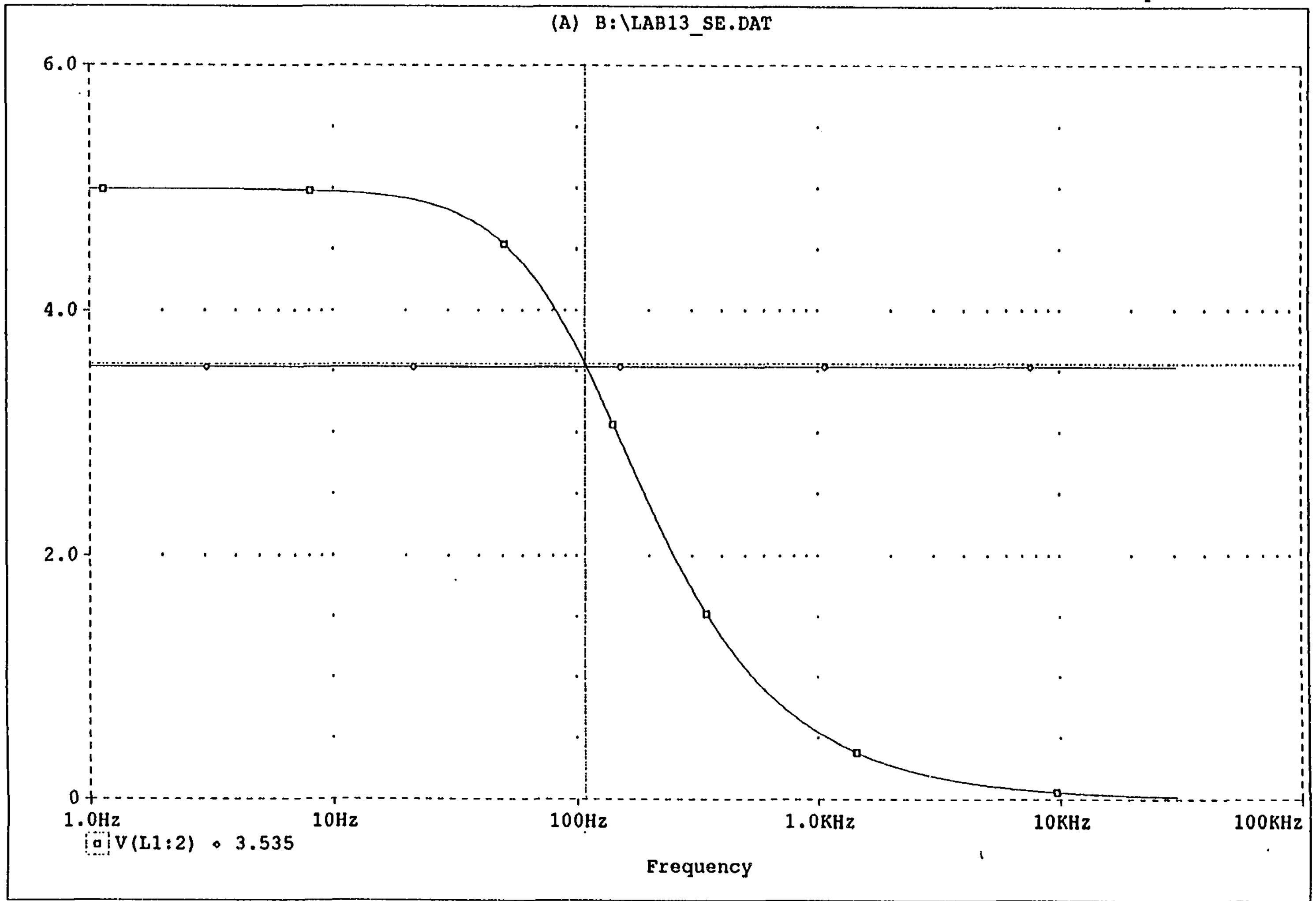

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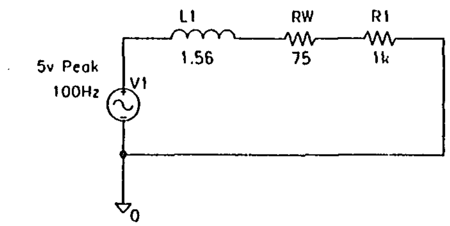

Iowa State University
Lab 10
IEDT 140

Page Size: A

Saeid Mostehpour

Reversion: 1.2   Nov 18, 1992   Page 1 of 1

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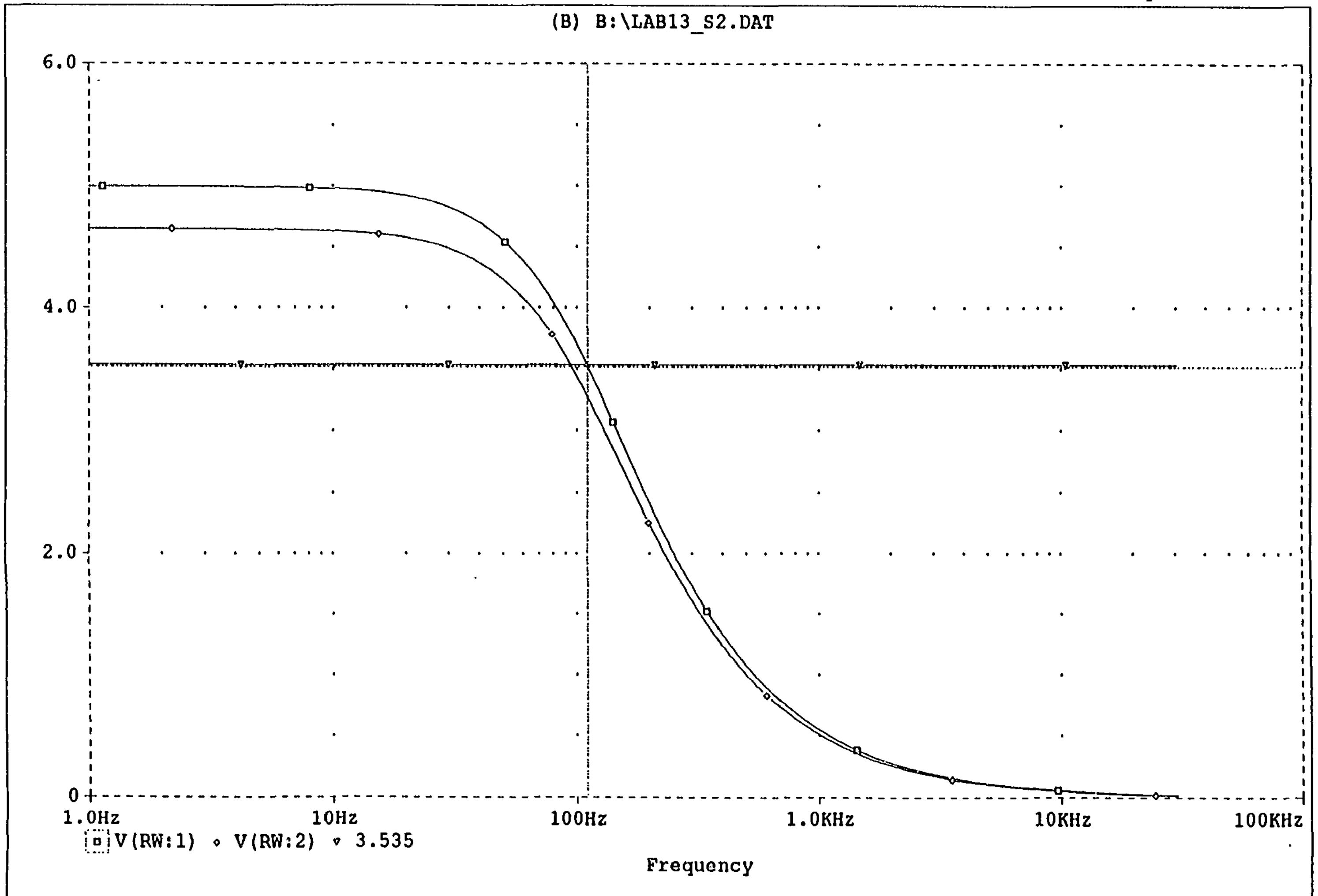

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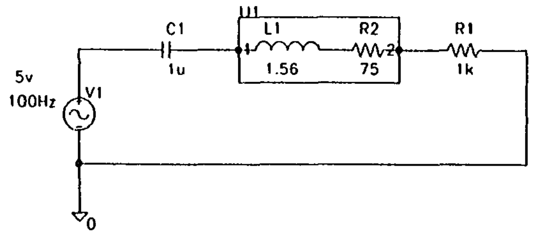

Iowa State University
Lab 11
IEDT 140

Page Size:, A

Saeid Moslehpour

Reversion 1.0 Nov 18, 1992 Page 1 of 1

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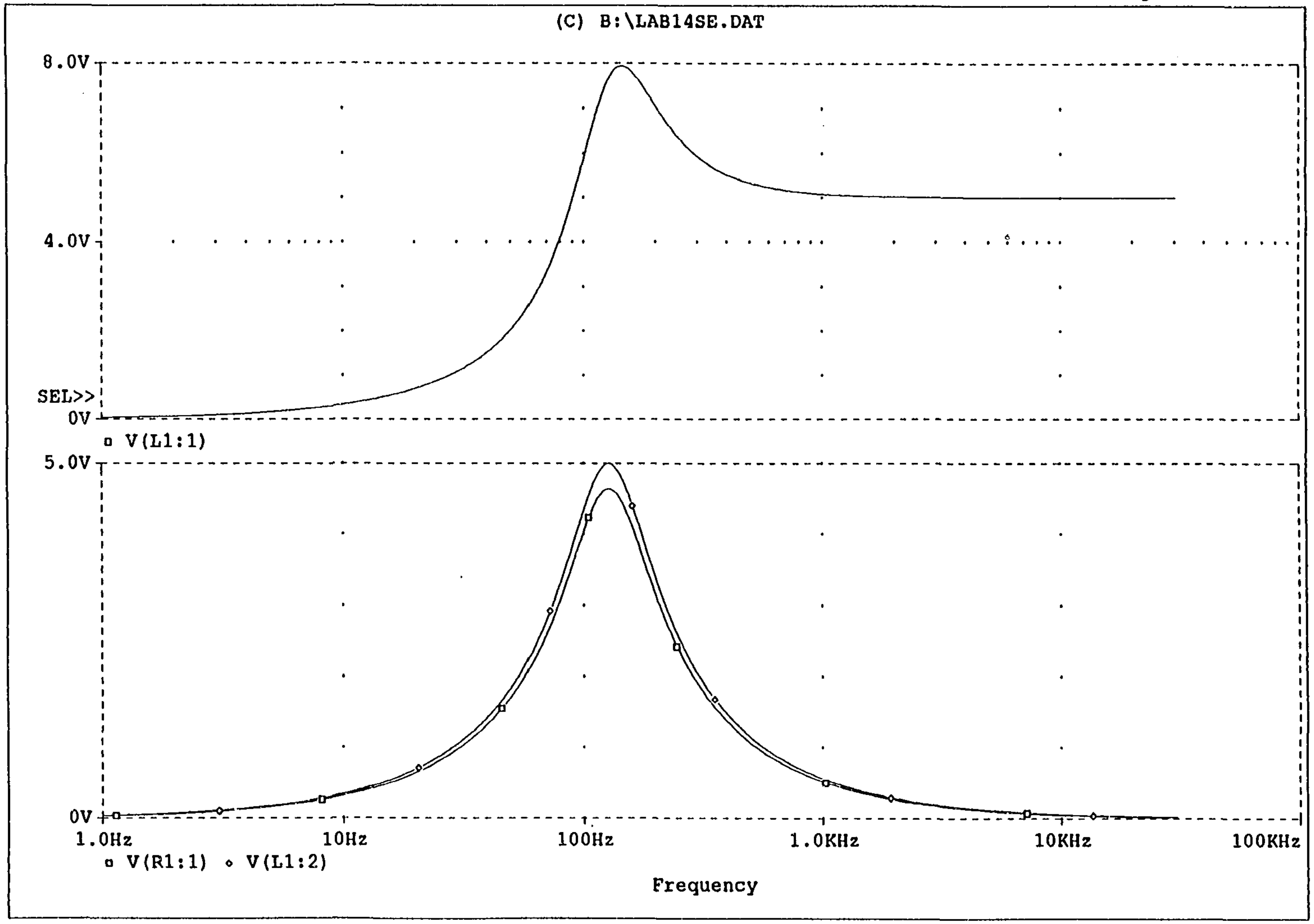

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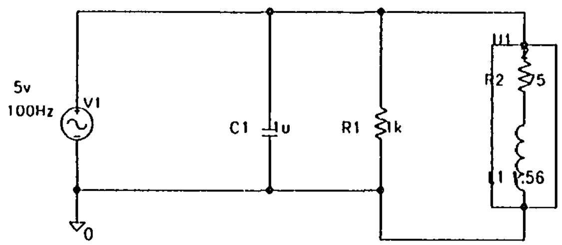

Iowa State University Lab 11 IEDT 140		Page Size: A
	Saeid Moslehpour	
Reversion: 1.3	Nov 18, 1992	Page 1 of 1

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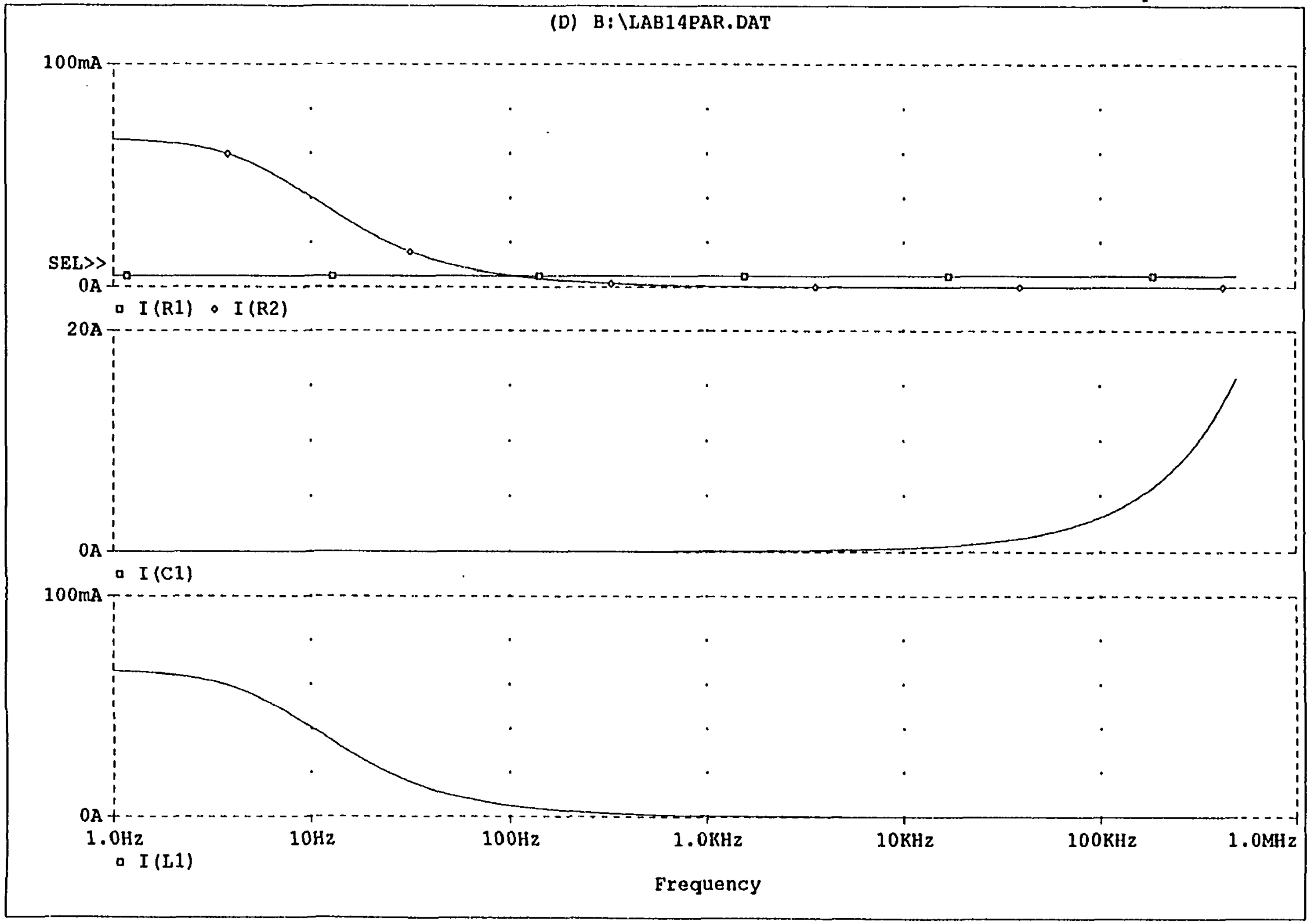

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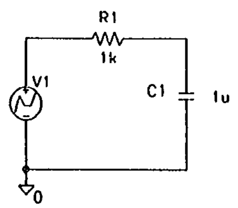

Iowa State University
Lab 12
IEDT 140

Page Size: A

Saeid Mostehpour

Revision: 1.1

December 1992 Page 1 of 1

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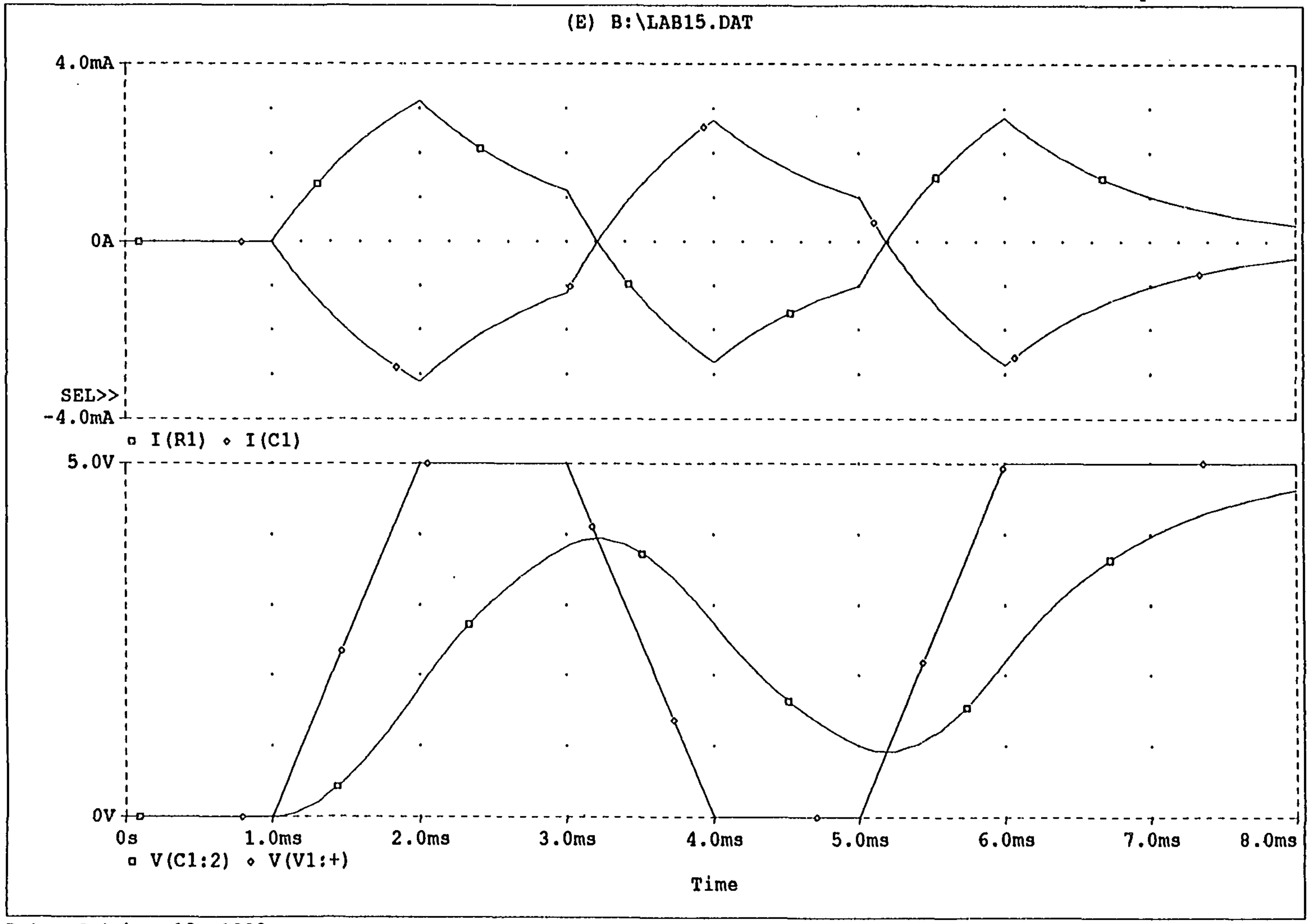

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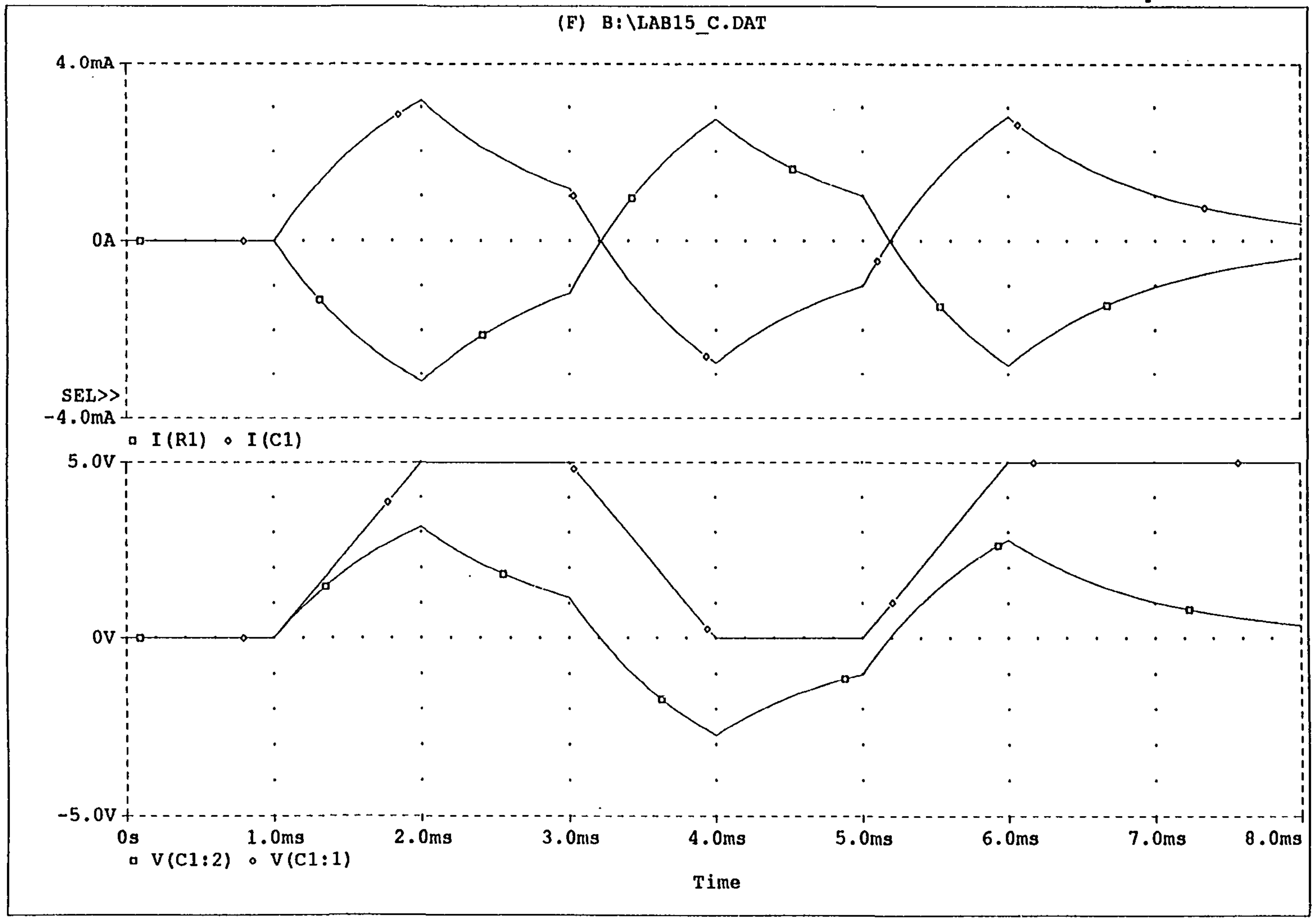

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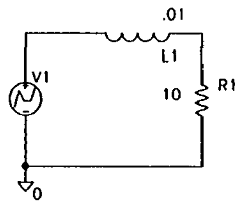

Iowa State University
Lab 12
IEDT 140

Page Size: A

Saeid Moslehpour

Revision: 1.0   December 1992 Page 1 of 1

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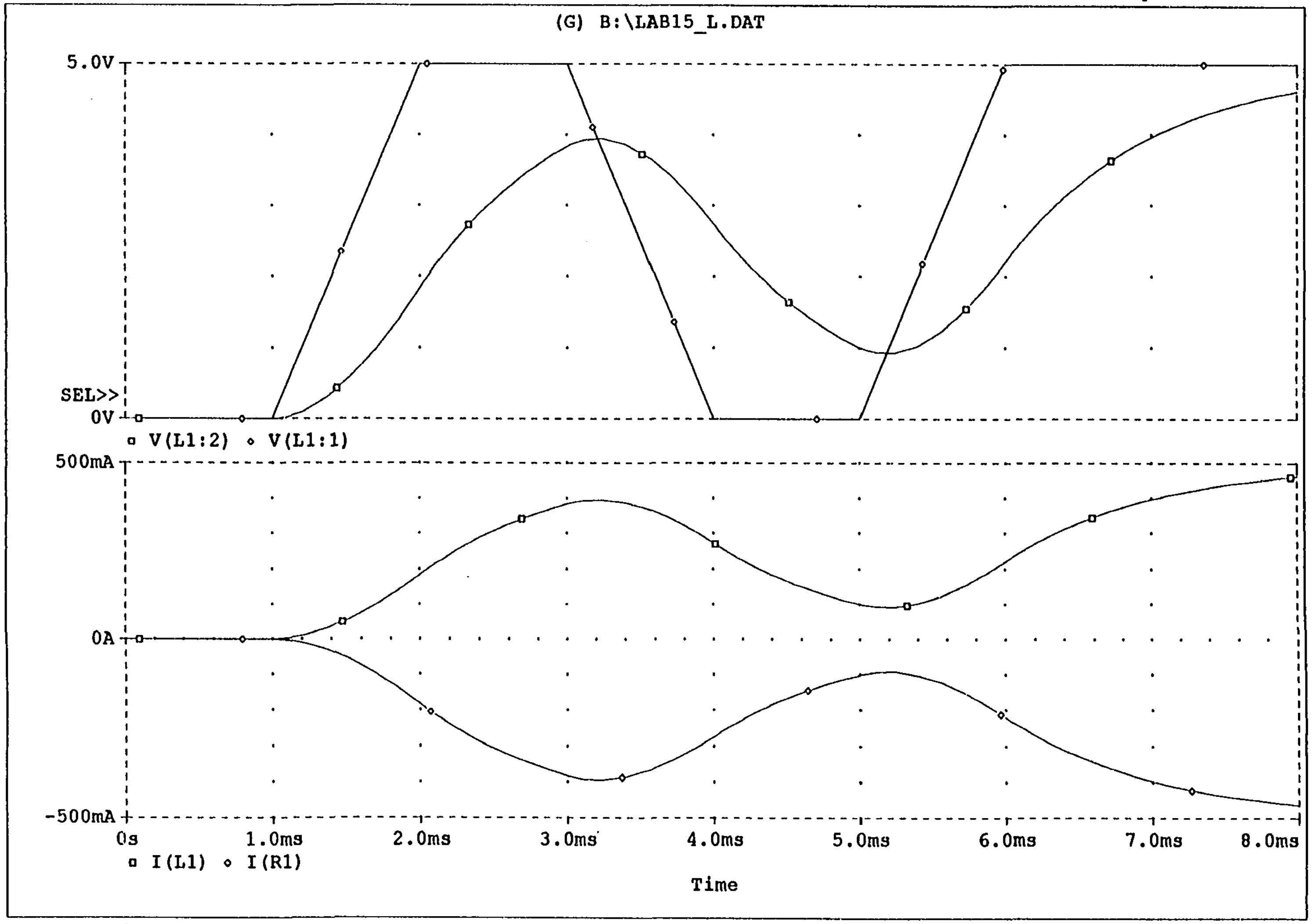

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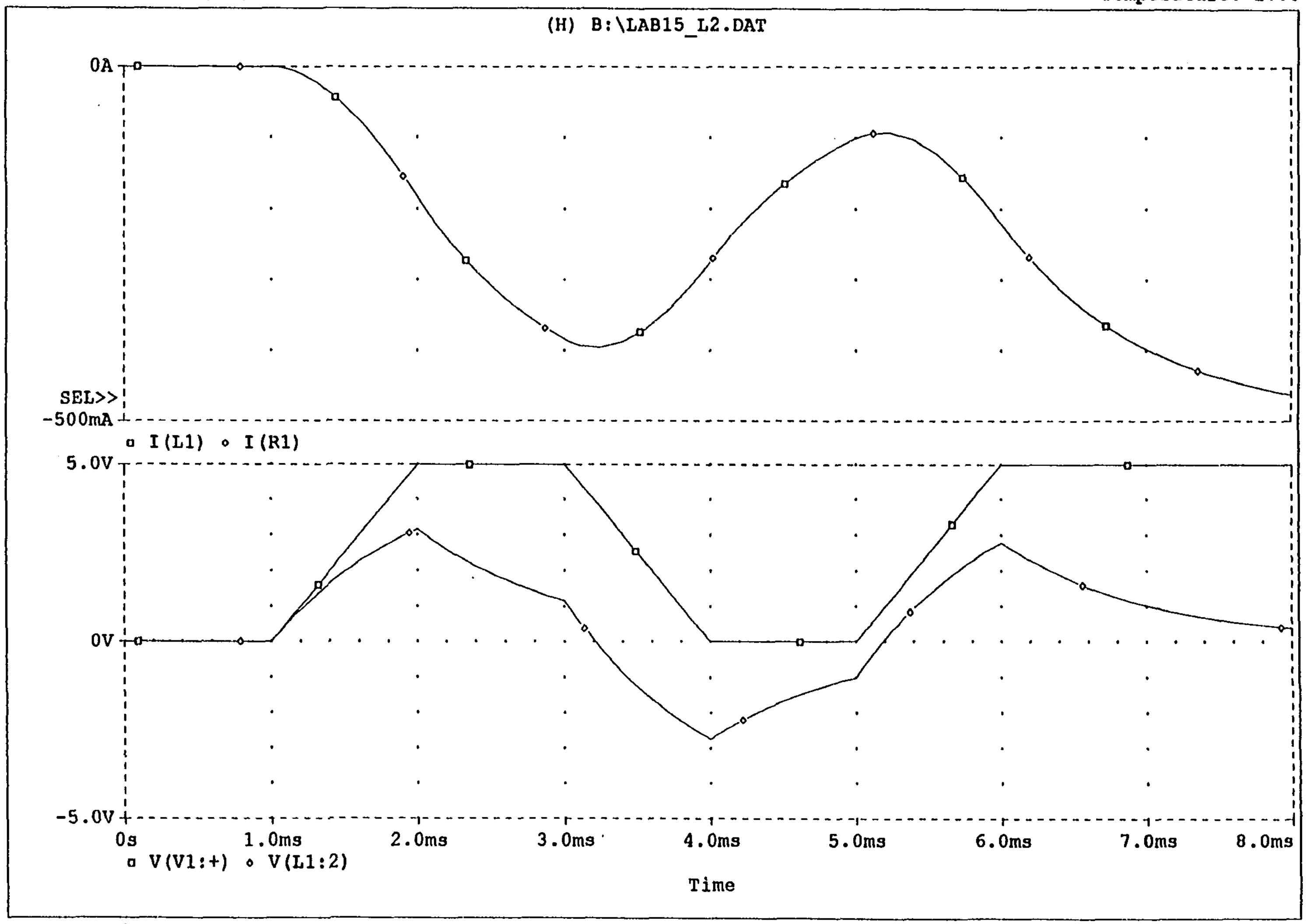

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APPENDIX C: PRETEST

Chapter 1: Introduction

1. The unit of resistance is the ohm.
   a. true
   b. false

2. 0.0047 amps can be expressed in metric units as 47 µA.
   a. true
   b. false

3. An electronic device which stores electric charge is known as an inductor.
   a. true
   b. false

4. The electrical symbol for inductance is
   a. C
   b. I
   c. V
   d. L

5. A device that changes ac voltages is known as
   a. a transistor.
   b. a capacitor.
   c. a transformer.
   d. an inductor.

6. A resistor
   a. stores a charge.
   b. opposes the flow of electrons.
   c. is a type of semiconductor.
   d. stores energy in a magnetic field.

7. The value $1.2\text{x}10^{-6}$ can be expressed as
   a. 0.00012
   b. 1.2 m or milli
   c. 1.2 µ or micro
   d. 1.2 M or Meg

8. Your calculator has given you an answer to a problem of 3.456 07 on the display. The correct metric value is
   a. 3.456 micro
   b. 3.456 Mega
   c. 34.56 mega
   d. 3.456 kilo

9. The metric value 16 mA can be expressed as
   a. $16\text{x}10^{-6}$
   b. $16\text{x}10^{3}$
   c. $16\text{x}10^{-3}$
   d. $16\text{x}10^{-0}$

10. Determine the correct calculation.
a. 5600 x (9.6×10^{-7}) = 5.376 milli
b. $4.7m/1.2\mu$ = 4207
c. 89.4k x 1.2m = 97.28
d. 5.6/17m = 32.9

11. The correct expression for 8.54×10^{-5} is
a. 854 pico
b. 85.4
c. 85.4 micro
d. 85.5 kilo

12. Express 7.5×10^{-4} in milli, basic units, and micro.

a. 7.5 milli	0.075	75000 micro
b. 75 milli	0.075	7500 micro
c. 75 milli	0.0075	750 micro
d. 0.75 milli	0.00075	750 micro

13. Express these two calculator displays in correct metric units. 5.6-07 2.2 05
a. 56 micro 22 kilo
b. 0.56 micro 0.022 Meg
c. 0.56 micro 220 kilo
d. 56 micro 220 kilo

14. An electrical symbol for voltage is
a. I
b. V
c. C
d. R

15. A typical semiconductor device is
a. the transformer.
b. the diode.
c. the resistor.
d. the capacitor.

16. An electronic device that resists the flow of current in a circuit is known as
a. a capacitor
b. an inductor
c. a resistor
d. a transformer

17. An electronic device that stores electric charge is
a. a transformer
b. a capacitor
c. a resistor
d. an inductor
e. a semiconductor

18. A device that stores energy electromagnetically is
    a. a capacitor
    b. an inductor
    c. a transistor
    d. a diode

19. You have just calculated an answer for a problem. Your calculator reads 3.5-06. The correct metric value is
    a. 35 milli
    b. 35 micro
    c. 3.5 Meg
    d. 3.5 micro
    e. 3.5 pico

20. Express 5.6×10^{-2} in milli, basic units, and micro.

a. 5.6 milli	0.056	56000
b. 56 milli	0.056	56000
c. 560 milli	5.6 00	5600
d. 5600 milli	56	560

Chapter 2: The Basic Electrical Quantities

1. The movement of free electrons along a conductor is called current.
   a. true
   b. false

2. Electrons attract each other.
   a. true
   b. false

3. A resistor color coded with bands of yellow, violet, and orange has a value of 4.7 kΩ.
   a. true
   b. false

4. A SPST switch is used to control one circuit.
   a. true
   b. false

5. To measure the current through a resistor, you place the ammeter so the current must pass through the meter.
   a. true
   b. false

6. The basic unit of resistance is the ohm.
   a. true
   b. false

7. A resistor color coded with bands of brown, black, and orange has a value of 10000 Ω.
   a. true
   b. false

8. A normally open push button switch could have current through it when not being pushed.
   a. true
   b. false

9. Electrons have a positive charge.
   a. true
   b. false

10. The opposition to the flow of current in a conductor is called resistance.
    a. true
    b. false

11. A material that has many free electrons is known as a/an
    a. conductor.
    b. insulator.
    c. semiconductor.
    d. poor conductor.

Chapter 2: The Basic Electrical Quantities

12. Opposition to the flow of current is called
    a. voltage.
    b. current.
    c. capacitance.
    d. resistance.

13. If you measure the current in a circuit and find it to be zero, it is probable that
    a. the circuit has a short.
    b. the power is turned off.
    c. the resistance is very low.
    d. the circuit voltage is very high.

14. A source, a path, and a load
    a. make up a basic circuit.
    b. can only be an open circuit.
    c. will allow current to flow if the switch is open.
    d. would be an incomplete circuit.

15. A definition of voltage is
    a. the opposition to the flow of current.
    b. the movement of free electrons.
    c. the force that exists between charged particles.
    d. the force that causes water to flow.

16. A unit of charge which contains 6.25×10^{18} electrons is known as
    a. an ampere.
    b. a joule.
    c. a volt.
    d. a coulomb.

17. A conductor is a material that has
    a. few free electrons.
    b. a positive charge.
    c. many free electrons.
    d. a structure similiar to semiconductors.

18. A resistor has a value of 1.2 Ω +/- 5%. It will be coded
    a. Brown, black, red, gold.
    b. Brown, black, silver, gold.
    c. Brown, black, gold, silver.
    d. Brown, red, gold, gold.

19. In figure 2-1, identify the DPST switch.
    a. A
    b. B
    c. C
    d. D
    e. E

Chapter 2: The Basic Electrical Quantities

20. A resistor is color coded with yellow, violet, orange, and silver bands has a value and tolerance of
a. 47 MΩ ± 10%
b. 47 kΩ ± 5%
c. 47 kΩ ± 10%
d. 4.7 kΩ ± 10%

21. A resistor is color coded with yellow, violet, orange, and gold bands has a value and tolerance of
a. 47 MΩ ± 10%
b. 47 kΩ ± 5%
c. 47 kΩ ± 10%
d. 4.7 kΩ ± 10%

22. A resistor is color coded with bands of orange, orange, orange, and silver. The value and upper and lower tolerance limits are
a. 33 kΩ, 32670--33330
b. 33 kΩ, 31350--34650
c. 33 kΩ, 29700--36300
d. 33 kΩ, 26400--39600

23. A resistor has a value of 100 kΩ ± 10%. It will be coded
a. black, brown, yellow, silver
b. brown, green, black, gold
c. brown, black, yellow, gold
d. brown, black, yellow, silver

24. See figure 2-2. The measured voltage V_{JK} is the same as
a. V_{R5}
b. V_{R6}
c. V_{R7}
d. V_{R8}

25. See figure 2-2. The measured voltage V_{FG} is the same as
a. V_{R6}
b. V_{R7}
c. V_{R8}
d. V_{R9}

26. See figure 2-2. Voltmeter leads placed across points C and D will read
a. V_{R1}
b. V_{R2}
c. V_{R3}
d. V_{R4}

27. See figure 2-2. The measured voltage V_{CE} is the same as
a. V_{R5}
b. $V_{R3} + V_{R4}$
c. $V_{R4} + V_{R5}$
d. V_{R6}

28. An analog ohmeter should
    a. be connected across a circuit with the power on.
    b. be inserted into the circuit so the current flows through it.
    c. placed across the resistance after the resistance is opened.
    d. have the polarity carefully checked before its use.

29. Most DMM's will measure __________, __________, and __________.
    a. frequency, voltage, current
    b. voltage, current, capacitance
    c. voltage, frequency, resistance
    d. voltage, current, resistance

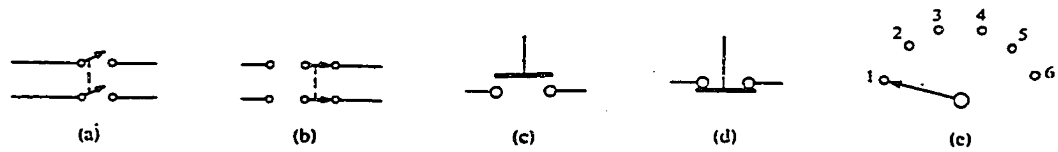


Figure 2-1

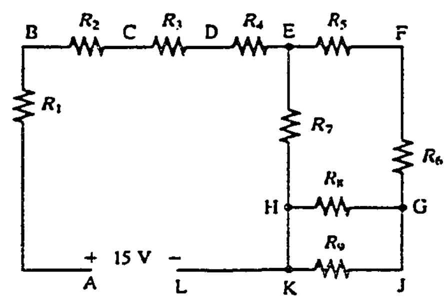


Figure 2-2

CHAPTER 1 QUIZ

Student Name____

1. Georg Simon Ohm developed Ohm's law around 1820.
   a. true
   b. false

2. Many careers exist for the electronic technician.
   a. true
   b. false

3. The unit of current is the ampere.
   a. true
   b. false

4. 15,000 V can be expressed in powers of ten as 15×10^3 V.
   a. true
   b. false

5. 0.0015 A can be expressed in metric units as 1.5 mA.
   a. true
   b. false

6. Some typical careers for electronic technicians are
   a. technical writers
   b. technical salespersons
   c. manufacturing technicians
   d. service shop technicians
   e. all of the above

7. A circuit component that resists the flow of current in a circuit is known as
   a. a capacitor
   b. an inductor
   c. a resistor
   d. a transformer

8. A circuit component that stores electric charge is
   a. a transformer
   b. a capacitor
   c. a resistor
   d. an inductor
   e. a semiconductor

9. Some semiconductor devices are
   a. transformers, transistors, and integrated circuits.
   b. diodes, transistors, and resistors.
   c. integrated circuits, inductors, and capacitors.
   d. integrated circuits, capacitors, and diodes.
   e. diodes, transistors, and integrated circuits.

10. The electrical symbol for capacitance is
    a. I
    b. V
    c. C
    d. Q
    e. E

11. The symbol A is an abbreviation for
    a. farad
    b. volt
    c. hertz
    d. henry
    e. ampere

12. A device that stores energy electromagnetically is
    a. a capacitor
    b. an inductor
    c. a transistor
    d. a diode

13. The symbol and unit for time is
    a. t, I
    b. C, f
    c. t, s
    d. Z, W

14. The value $4.7 \times 10^3\ \Omega$ can be expressed as
    a. $0.00047\ \Omega$
    b. $4.7\ k\Omega$
    c. $4.7\ \Omega$
    d. $4.7\ M\Omega$

15. You have just calculated an answer for a problem. Your calculator reads 3.5-06. The correct metric value is
    a. 35 milli-
    b. 35 micro-
    c. 3.5 mega-
    d. 3.5 micro-
    e. 3.5 pico-

16. You are trying to enter 45,600 Ω into your calculator. A correct entry might be
   a. 4.56 03
   b. 4.56-03
   c. 456 01
   d. 4.56 04
   e. 45.6 05

17. Your calculator gives you an answer on its display of 1.2 05. A correct metric value of resistance for this answer is
   a. 12 kΩ
   b. 0.12 MΩ
   c. 12,000 Ω
   d. 1200 Ω

18. The correct expression for 7.84×10^{-8} F is
   a. 784 pF
   b. 0.0784 μF
   c. 7.84 μF
   d. 7840 μF

19. Express these calculator displays in correct metric values: 4.7-06, 1.5 04, 9.5-03.

a.	47 milli-	15000	9.5 milli-
b.	470	1500	0.095 micro-
c.	4.7 micro-	15 kilo-	9.5 milli-
d.	470 milli-	15 kilo-	9.5 milli-

20. Express 5.6×10^{-2} in milli-, basic units, and micro-.

a.	5.6	0.056	56000
b.	56	0.056	56000
c.	560	5.6	5600
d.	5600	56	560

CHAPTER 2 QUIZ

Student Name____

1. The movement of free electrons along a conductor is called voltage.
   a. true
   b. false

2. Electrons repel each other.
   a. true
   b. false

3. A resistor color coded with bands of red, red, orange has a value of 2.2 kΩ.
   a. true
   b. false

4. Generally, digital meters are not as accurate as analog meters.
   a. true
   b. false

5. To measure the current through a resistor, you place the ammeter across the resistor.
   a. true
   b. false

6. A conductor is a material that has
   a. few free electrons.
   b. a positive charge.
   c. many free electrons.
   d. a structure similar to semiconductors.

7. A material with few free electrons is known as
   a. a conductor.
   b. an insulator.
   c. a semiconductor.

8. A resistor color coded with yellow, violet, red, and silver bands has a value and tolerance of

   a. 47 MΩ +/- 10%
   b. 4.7 kΩ +/- 5%
   c. 4700 Ω +/- 5%
   d. 0.0047 MΩ +/- 10%

9. A resistor has a value of 1.2 Ω +/- 5%. It will be coded
   a. brown, black, red, gold.
   b. brown, black, silver, gold.
   c. brown, black, gold, silver.
   d. brown, red, gold, gold.

10. A definition of resistance is
   a. the ability to store a charge.
   b. the opposition to the flow of current.
   c. the movement of free electrons.
   d. the potential difference across a source.

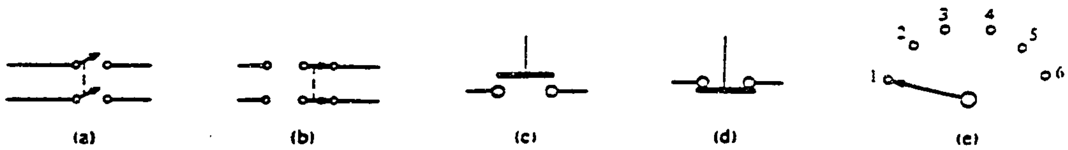


FIGURE 2-1

11. In Figure 2-1, identify the DPST switch.
   a. A
   b. B
   c. C
   d. D
   e. E

12. In Figure 2-1, identify the normally closed push button switch.
   a. A
   b. B
   c. C
   d. D
   e. E

13. In Figure 2-1, identify the DPDT switch.
   a. A
   b. B
   c. C
   d. D
   e. E

14. A complete basic electrical circuit consists of
   a. a source, a load, and a resistor.
   b. a battery, a resistor, and a capacitor.
   c. a source, a load, and a path.
   d. a battery, a path, and a switch.

15. In order to measure the current in a circuit, the ammeter
    a. must be placed across the load.
    b. must be placed so the current must pass through the meter.
    c. must be placed across the source.
    d. should not be used. A voltmeter is the correct instrument.

16. The most common type of diagram used in electronic work is
    a. a pictorial diagram.
    b. a wiring diagram.
    c. a schematic diagram.
    d. a three-view diagram.

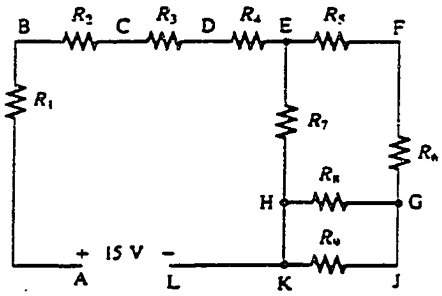


FIGURE 2-2

17. See Figure 2-2. If you place the red lead of a voltmeter on point F and the black lead on point G, you will read
    a. V_{R5}
    b. I_{R5}
    c. V_{R8}
    d. V_{R6}

18. See Figure 2-2. To measure the current through R_3, the circuit must be opened and the meter placed at point
    a. A
    b. E
    c. J
    d. H

19. See Figure 2-2. Voltmeter leads placed across points E and G will read
    a. V_{R6}
    b. V_{R4}
    c. $V_{R7} + V_{R8}$
    d. V_{R7}

20. See Figure 2-2. The measured voltage V_{HG} is the same as
    a. V_{R7}
    b. V_{R8}
    c. V_{R5}
    d. V_{R9}

APPENDIX D: POSTTESTS (HOMEWORK)

Chapter 3: Ohm's Law and Power

1. If the current is constant then voltage and resistance are directly proportional.
   a. true
   b. false

2. A circuit has a supply voltage of 15 V. The resistance is 4700 Ω. The current is 313 mA.
   a. true
   b. false

3. A 1 kΩ resistor has 32 mA flowing through it. The resistor is dissipating 1.024 W.
   a. true
   b. false

4. If the resistance in a circuit increases, then the current will decrease.
   a. true
   b. false

5. A 47 kΩ resistor has 5 mA flowing through it. It is OK to use a resistor with a power rating of 1 W.
   a. true
   b. false

6. A circuit has a supply voltage of 20 V and a resistance of 3300 Ω. The current is 6.06 mA.
   a. true
   b. false

7. A 2.5 kΩ resistor has 45 mA flowing through it. The resistor is dissipating 112.5 W.
   a. true
   b. false

8. If the resistance in a circuit decreases, then the current will also decrease.
   a. true
   b. false

9. A 56 kΩ resistor has 10 mA flowing through it. It is OK to use a resistor with a power rating of 10 W.
   a. true
   b. false

10. A circuit has a resistor of 12 kΩ with a current of 12 mA flowing through it. The circuit voltage is 1 V.
    a. true
    b. false

Chapter 3: Ohm's Law and Power

11. Voltage and current are
    a. directly proportional.
    b. inversley proportional.
    c. not related.
    d. quantities that add.

12. If the voltage across a circuit increases, then
    a. the current decreases.
    b. the resistance increases.
    c. the resistance decreases.
    d. the current increases.

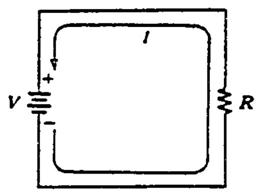


Figure 3-1

13. See figure 3-1. If V = 25 V, and R = 50 kΩ, the current would equal
    a. 50 mA
    b. 5 mA
    c. .5 mA
    d. 2 mA

14. See figure 3-1. If I = 64 mA, and R = 470 Ω, the voltage would equal
    a. 30.08 V
    b. 3.008 V
    c. 73.43 V
    d. 7.343 V

15. See figure 3-1. If V = 72 V, and I = 12 mA, the resistance would equal
    a. 0.166 Ω
    b. 6 kΩ
    c. 864 Ω
    d. 47 kΩ

16. See figure 3-1. V = 12 V and R = 12 kΩ If the resistor shorts, the current will be
    a. 1 mA
    b. 10 mA
    c, 0 mA
    d. extremely large

Chapter 3: Ohm's Law and Power

17. See figure 3-1. If the voltage were suddenly switched off,
    a. the current will be zero.
    b. the current will gradually decrease to zero.
    c. the current will first increase and then decrease to zero.
    d. there is no way to predict the current.

18. See figure 3-1. If V = 100 V and I = 1 mA, then the power dissipated by the resistor is
    a. 10 W
    b. 1 W
    c. 100 mW
    d. 10 mW

19. A circuit consists of a resistor color coded yellow, violet, orange, and gold. This resistor is placed across a source of 15 V. What value of resistor and wattage rating could be used?
    a. 4.7 kΩ at 1/8 W
    b. 47 kΩ at 1/4 W
    c. 4700 Ω at 1/4 W
    d. 0.47 MΩ at 1/4 W

20. A 220 Ω, 1/2 W resistor has burned and is open. You look in your parts box and find the following resistors. Which resistor could you use to repair the circuit?
    a. 2200 Ω, 1/2 W
    b. 220 Ω, 1/4 W
    c. 220 Ω, 1/8 W
    d. 220 Ω, 1 W

21. See figure 3-1. If the resistor opens,
    a. the power dissipated will decrease.
    b. the current will increase.
    c. the resistance will decrease.
    d. the voltage will increase.

22. A 100 watt light bulb has a resistance measurement of 56 Ω when out of the circuit. What is the resistance of the bulb when it is on and in a circuit with a supply of 120 V?
    a. 56 Ω
    b. 2.14 Ω
    c. 144 Ω
    d. 560 Ω

23. A rating of 1/2 W for a resistor means that the resistor
    a. can safely dissipate 1/2 W of power.
    b. always dissipates 1/2 W.
    c. always provides 1/2 W of power.
    d. can only dissipate more that 1/2 W of power.

Chapter 3: Ohm's Law and Power

24. Which is the correct formula for Ohm's Law?
    a. V = I/R
    b. R = VI
    c. I = V/R
    d. P = VI

25. A resistor color coded yellow, violet, brown, and gold is connected to a 12 V source. If the resistor is within tolerance, what is the maximum current that will flow?
    a. 24.3 mA
    b. 25.5 mA
    c. 26.9 mA
    d. 255 mA

26. Resistance and current are
    a. directly proportional.
    b. inversely proportional.
    c. not related.
    d. are similar to voltage.

27. See figure 3-1. If I = 32 mA, and R = 469 Ω then V =
    a. 12 V
    b. 15 V
    c. 19 V
    d. 22 V

28. Which of the following terms is not a resistor rating.
    a. resistor value in ohms
    b. resistor tolerance.
    c. current
    d. power rating

29. See figure 3-1. V = 12 V and R is color coded brown, black, orange. You measure the current in the circuit. What limits of current might you expect to measure?
    a. 1.2 mA and 1.4 mA
    b. 1 mA and 1.6 mA
    c. 0.8 mA and 1.2 mA
    d. 1 ma and 1.5 ma

30. See figure 3-1. If the resistor develops an open,
    a. the power dissipated will increase.
    b. the circuit current will decrease.
    c. the source voltage will decrease to zero.
    d. the resistance will decrease.

31. A currentof 250 µA through a 4.7 kΩ resistor produces a voltage drop of
    a. 53.2 V
    b. 1.175 mV
    c. 18.8 V
    d. 1.175 V

Chapter 3: Ohm's Law and Power

32. A resistance of 2.2 MΩ is connected across a 1 kV source. The resulting current is approximately
    a. 2.2 mA
    b. 0.455 mA
    c. 45.5 µA
    d. 0.455 A

33. A 2.2 kΩ resistor dissipates 0.5 W. The current is
    a. 15.1 mA
    b. 0.227 mA
    c. 1.1 mA
    d. 4.4 mA

34. A 330 Ω resistor dissipates 2 W. The voltage is
    a. 2.57 V
    b. 660 V
    c. 6.6 V
    d. 25.7 V

35. The power rating of a carbon-composition resistor that is to handle up to 1.1 W should be
    a. 0.25 W
    b. 1 W
    c. 2 W
    d. 5 W

Chapter 4: Series Circuits

1. In a series circuit, the current is the same everywhere in the circuit.
   a. true
   b. false

2. Kirchoff's Voltage Law states that the product of the individual voltage drops equals the source voltage.
   a. true
   b. false

3. The total power dissipated in a series circuit is the sum of the individual powers.
   a. true
   b. false

4. Three resistors, 6.8 kΩ, 1.2 kΩ, and 5.6 kΩ are in series. The total resistance is 13.6 kΩ.
   a. true
   b. false

5. A resistor is dissipating 1/4 W. This means that it can supply 1/4 W to the load.
   a. true
   b. false

6. Three resistors, 4.7 kΩ, 2.2 kΩ, and 1.2 kΩ are in series. The total resistance is 8.7 kΩ.
   a. true
   b. false

7. The total power dissipated in a series circuit is equal to the source voltage multiplied by the current.
   a. true
   b. false

8. A resistor is rated at 1/2 W. This resistor can safely dissipate 0.325 W.
   a. true
   b. false

9. The sum of the individual voltage drops in a series circuit equals the source voltage. This statement is Kirchhoff's Law.
   a. true
   b. false

10. Two resistors are in series. One is a 1/4 W resistor and the other is a 1/2 W resistor. This circuit can safely dissipate 1 3/4 W.
    a. true
    b. false

Chapter 4: Series Circuits

11. See figure 4-1. R_1 = 10 kΩ, R_2 = 10 kΩ and R_3 = 15 kΩ. What is the total resistance, R_T?
a. 25 kΩ
b. 35 kΩ
c. 0 Ω
d. infinite Ω

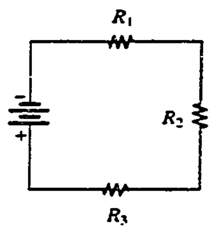


Figure 4-1

12. See figure 4-1. R_1 = 10 kΩ, V_{R1} =16 V, R_2 =10 kΩ, R_3 =15 Ω. Calculate the current in the circuit.
a. 3.2 mA
b. 1.6 mA
c. 0
d. 12 mA

13. See figure 4-1. R_1 = 10 kΩ, V_{R1} = 16 V, R_2 = 10 kΩ, R_3 = 15 kΩ. Calculate the voltage drops across R_2 and R_3.
a. V_{R2} = 16 V V_{R3} = 12 V
b. V_{R2} = 16 V V_{R3} = 24 V
c. V_{R2} = 16 V V_{R3} = 16 V
d. V_{R2} = 24 V V_{R3} = 12 V

14. See figure 4-1. R_1 = 10 kΩ, V_{R1} = 16 V, R_2 = 10 kΩ, R_3 = 15 kΩ The power dissipated in R_2 is
a. 25.6 mW
b. 2.56 mW
c. .256 mW
d. .0256 mW

15. See figure 4-1. R_1 = 10 kΩ, V_{R1} = 16 V, R_2 = 10 kΩ, R_3 = 15 kΩ The supply voltage V_S is
a. 16 V
b. 24 V
c. 56 V
d. 112 V

Chapter 4: Series Circuits

16. See figure 4-1. R_1 = 10 kΩ, V_{R1} = 16 V, R_2 = 10 kΩ, R_3 = 15 kΩ The total circuit resistance if R_2 opens is
a. 25 kΩ
b. 10 kΩ
c. 0 Ω
d. infinite Ω

17. See figure 4-1. If R_2 opens, the total power dissipated by the circuit will
a. increase
b. decrease
c. remain the same
d. will be dependent upon the source voltage.

18. Two power supplies are in series with voltages of 16 V and −12 V, respectively. What is the total supply voltage?
a. 28 V
b. −4 V
c. −28 V
d. 4 V

19. Two sources, 12 V and −19 V are connected so the total voltage is −7 V. These sources are said to be
a. series aiding.
b. series opposing.
c. in parallel.
d. dangerous to connect.

20. Three 47 kΩ resistors are connected in series across a 100 V source. Find P_T.
a. 70.9 mW
b. 23.6 mW
c. 22 W
d. 709 mW

21. Three resistors are connected in series across a 50 V source. The voltage drop across one of the resistors is 19.7 V and the drop across the another is 2.7 V. What is the drop across the third resistor?
a. 30.3 V
b. 47.3 V
c. 22.4 V
d. 27.6 V

22. The polarity of voltages across a resistor is dependent on the current direction. The resistor end where current enters is said to be ___________, and the other end is __________.
a. positive, positive
b. negative, negative
c. negative, positive
d. positive, negative

Chapter 4: Series Circuits

23. A series circuit with four resistors connected across a 50 V source, has a current of 100 μA flowing through it. The values for three of the resistors are 12 kΩ, 47 kΩ, and 56 kΩ. What is the value of the fourth resistor?
a. 38.5 kΩ
b. 3.85 kΩ
c. 385 kΩ
d. 3.85 MΩ

24. Two resistors are in series. R_1 = 12 kΩ and R_2 = 5 kΩ. A source voltage of 20 V is applied. V_{R1} will be ____________, and V_{R2} will be ____________.
a. 5.88 V, 14.12 V
b. 14.12 V, 5.88 V
c. 10 V, 10 V
d. 0 V, 20 V

25. Four resistors are connected in series across a source of 18 V. You measure the voltage across each resistor and find the voltage to be 0 V across three of them but 18 V across the last. What is the problem?
a. Two of the resistors are shorted
b. The three resistors are open.
c. One resistor is open.
d. No problem, this is normal.

26. Two power supplies are in series with voltages of 12 V and 17 V respectively. What is the total supply voltage?
a. 5 V
b. -5 V
c. 29 V
d. -29 V

27. Two resistors are in series across a source of 20 volts. Each resistor has a value of 100 kΩ. What is the voltage across each resistor?
a. 20 V
b. 10 V
c. 100 mA
d. 100 kΩ

28. A two-resistor voltage divider has R_1 = 22 kΩ and R_2 = 12 kΩ is connected across 47 volts. What is the voltage across R_2?
a. about 16.6 V
b. about 30.4 V
c. about 25.6 V
d. about 17.2 V

Chapter 4: Series Circuits

29. A 500 kΩ potentiometer is connected across 5 V. The voltage from the wiper to the lower end of the pot is 1.2 V. What is the resistance of the lower part of the potentiometer?
a. 380 kΩ
b. 120 kΩ
c. 500 kΩ
d. 0 Ω

30. Three batteries are in series with potentials of −1.2 V, 5 V, and 6 V. The total supply voltage is
a. 12.2 V
b. 9.8 V
c. 1.2 V
d. 1.3 V

31. A series circuit consists of three resistors with values of 100 Ω, 220 Ω, and 330 Ω. The total resistance is
a. less, than 100 Ω
b. the average of the values
c. 650 Ω
d. 1650 Ω

32. A 9 V battery is connected across a series combination of 68 Ω, 33 Ω, 100 Ω, and 47 Ω resistors. The amount of current is
a. 36.3 mA
b. 27.56 A
c. 22.32 mA
d. 326.6 mA

33. There are six resistors in a given series circuit and each resistor has 5 V dropped across it. The source voltage is
a. 5 V
b. 30 V
c. dependent on the resistor values
d. dependent on the current

34. A series circuit consists of a 4.7 kΩ, a 5.6 kΩ, and a 10 kΩ resistor. The resistor that has the most voltage across it is
a. the 4.7 kΩ
b. the 5.6 kΩ
c. the 10 kΩ
d. impossible to determine from the given information

35. The total power in a certain circuit is 10 W. Each of the five equal-value series resistors making up the circuit dissipates
a. 10 W
b. 50 W
c. 5 W
d. 2 W

Chapter 5: Parallel Circuits

1. Three equal resistors are connected in parallel. The source voltage is 12 V. The voltage across each resistor is 4 V.
   a. true
   b. false

2. The total resistance of four resistors in parallel is always less than the smallest resistor.
   a. true
   b. false

3. A parallel branch has 0.065 mA flowing and the other branch has 0.098 mA flowing. The total current is 0.163 mA.
   a. true
   b. false

4. If one branch of a parallel circuit opens, the total resistance will decrease.
   a. true
   b. false

5. The total power dissipation of resistors in parallel can be found by adding the individual powers.
   a. true
   b. false

6. Three equal resistors are connected in parallel. The source voltage is 18 V. The voltage across each resistor is 6 V.
   a. true
   b. false

7. The total resistance of three resistors in parallel is the sum of the individual resistor values.
   a. true
   b. false

8. A parallel branch has a current of 75 mA and another branch has a current of 12.7 mA. The total current is 85.7 mA.
   a. true
   b. false

9. If one branch of a parallel circuit shorts, the total resistance will decrease.
   a. true
   b. false

10. Two resistors are in parallel. One is dissipating 0.25 W and the other is dissipating 1.2 W. The total power dissipated is 1.25 W.
    a. true
    b. false

Chapter 5: Parallel Circuits

11. Three resistors are connected in parallel. The values are 5.5 kΩ, 22 kΩ, and 500 Ω. What is R_T?
a. 28.1 kΩ
b. 27.6 kΩ
c. 450 Ω
d. 330 Ω

12. Three resistors, 500 Ω, 1200 Ω, and 10 kΩ, are connected in parallel across 25 V. What is the current through the 1200 Ω resistor?
a. 20.83 mA
b. 50 mA
c. 2.5 mA
d. 2.4 mA

13. Two resistors are in parallel, 2.2 kΩ and 3.3 kΩ. The total resistance of the circuit is
a. 2.2 kΩ
b. 3.3 kΩ
c. greater than 2.2 kΩ
d. less than 2.2 kΩ

14. A parallel circuit consists of R_1 = 0.22 MΩ, R_2 = 1 MΩ, and R_3. If R_T = 0.1166 MΩ, find R_3.
a. 1.34 MΩ
b. 0.33 MΩ
c. 0.134 MΩ
d. 13,400 Ω

15. Three resistors are connected in parallel across 18 V. The values are 1 MΩ, 0.470 MΩ, and 0.5 MΩ. If the 1 MΩ resistor opens, the total current will be
a. 74.3 μA.
b. 74.3 mA.
c. 92.3 μA.
d. 92.3 mA.

16. Twelve 1.5 MΩ resistors are connected in parallel across 50 V. What is R_T?
a. 1.5 MΩ
b. 1.25 MΩ
c. 1 MΩ
d. 0.125 MΩ

17. A parallel circuit with three resistors in parallel has a total current of 0.1 mA. If I_1 = 0.022 mA and I_2 = 0.007 mA, what is the current through the third resistor, I_3?
a. 0.029 mA
b. 0.071 mA
c. 0.142 mA
d. 0.213 mA

Chapter 5: Parallel Circuits

18. Four resistors are connected in parallel. If one resistor opens, the total resistance will and the total current will
a. decrease, increase
b. increase, increase
c. decrease, decrease
d. increase, decrease

19. Three 22 kΩ resistors are connected in parallel across a 10 V source. P_T equals
a. 4.5 mW.
b. 13.6 mW.
c. 18.1 mW.
d. 22.6 mW.

20. If a resistor in parallel shorts, the total current will
a. equal 0.
b. increase.
c. decrease.
d. decrease, then increase to 0.

21. Four 100 W lamps are connected in parallel across 120 V. What is the total current to the circuit?
a. 3.33 A
b. 833 mA
c. 33.3 A
d. 8.33 A

22. You have a circuit with four resistors in parallel. You measure the total current and find that it is lower than normal. Which statement best describes a possible trouble?
a. One of the resistors shorted.
b. The power supply is off.
c. All of the resistors opened.
d. One resistor opened.

23. A correct formula concerning a parallel circuit with two branches is
a. $R_T = R_1 + R_2$
b. $V_T = V_1 + V_2$
c. $I_T = I_1 + I_2$
d. $R_T = V_1/I_2$

24. The current through any branch of a parallel circuit is
a. dependent on the power rating of the resistor.
b. only dependent on the circuit voltage.
c. directly proportional to the branch resistance.
d. inversely proportional to the branch resistance.

Chapter 5: Parallel Circuits

25. If you want to measure a voltage across a load with a DVM, the meter is connected
a. in series with the load.
b. across the source.
c. in parallel with the load.
d. in series with the source.

26. A parallel circuit consisting of R_1 = 100 Ω, R_2 = 500 Ω and R_3 has an R_T = 76.92 Ω. Find the value of R_3.
a. 140 Ω
b. 1000 Ω
c. 1850 Ω
d. Cannot compute; not enough data.

27. A parallel circuit consists of R1 = 1200 Ω in parallel with R_2. I_T = 0.005 mA, I_2 = 0.003 mA. What is the value of V_{R1}?
a. 6 mV
b. 18 mV
c. 3.6 mV
d. 2.4 mV

28. As resistors are added in parallel to a circuit,
a. I_T decreases and R_T increases.
b. I_T decreases and R_T decreases.
c. I_T increases and R_T decreases.
d. I_T increases and R_T increases.

29. A circuit consists of three resistors in parallel, R_1 = 4.7 kΩ, R_2 = 3.3 kΩ, and R_3 = 5.43 kΩ. I_T = 35 mA and V_S = 50 V. Find I_{R3}.
a. 10.64 mA
b. 15.15 mA
c. 9.21 mA
d. 4.72 mA

30. Two resistors are in parallel. R_1 = 470 Ω and R_T = 330 Ω. Find the value of R_2.
a. 770 Ω
b. 1108 Ω
c. 194 Ω
d. 110 Ω

31. A 330 Ω resistor, a 270 Ω resistor and a 68 Ω resistor are all in parallel. The total resistance is approximately
a. 668 Ω
b. 47 Ω
c. 68 Ω
d. 22 Ω

Chapter 5: Parallel Circuits

32. The currents into a junction flow along two paths. One current is 5 A and the other is 3 A. The total current out of the junction is
    a. 2 A
    b. unknown
    c. 8 A
    d. the larger of the two

33. In a four-branch parallel circuit, there is 10 mA of current in each branch. If one of the branches opens, the current in each of the other three branches is
    a. 13.33 mA
    b. 10 mA
    c. 0 A
    d. 30 mA

34. If there is a total of 100 mA into a parallel circuit consisting of three branches and two of the branch currents are 40 mA and 20 mA, the third branch current is
    a. 60 mA
    b. 20 mA
    c. 160 mA
    d. 40 mA

35. The power dissipation in each of four parallel branches is 1 W. The total power dissipation is
    a. 1 W
    b. 4 W
    c. 0.25 W

Chapter 6: Series-Parallel Circuits

1. See figure 6-1. R_2 is in parallel with R_3.
   a. true
   b. false

2. See figure 6-1. R_1 is in series with R_3.
   a. true
   b. false

3. See figure 6-1. R_1 is in series with the parallel combination R_2 and R_3.
   a. true
   b. false

4. Resistors are in parallel if they share the same voltage.
   a. true
   b. false

5. A combination circuit consists of resistors in both series and parallel.
   a. true
   b. false

6. See figure 6-1. R_1 is in series with the series combination R_2 and R_3.
   a. true
   b. false

7. No problems could occur if a voltage source of 10 V were tc be connected in parallel with a 20 V source.
   a. true
   b. false

8. A loaded voltage divider is a combination circuit.
   a. true
   b. false

9. Two or more resistors connected in series form a circuit known as a voltage divider.
   a. true
   b. false

10. Resistors are in parallel if they share the same current.
    a. true
    b. false

Chapter 6: Series-Parallel Circuits

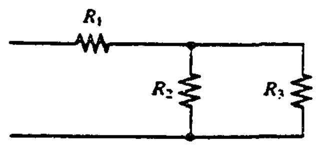


Figure 6-1

11. See figure 6-1. Resistor R_2 is connected
    a. in series with R_1.
    b. in series with R_3.
    c. in parallel with R_1.
    d. in parallel with R_3.

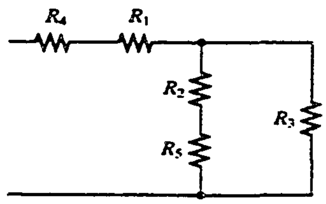


Figure 6-2

12. See figure 6-2. R_2 and R_5 are connected
    a. in series with each other and R_3.
    b. in series with each other and R_1 and R_4.
    c. in series.
    d. in parallel with R_3.

13. See figure 6-2. If all of the resistors are 4.7 kΩ, find R_T.
    a. 12.53 kΩ
    b. 18.8 kΩ
    c. 9.4 kΩ
    d. 4.7 kΩ

14. See figure 6-2. R_1, R_2, and R_3 each equal 10 kΩ. R_4 and R_5 each equal 50 kΩ. Find R_T.
    a. 8.57 kΩ
    b. 130 kΩ
    c. 68.57 kΩ
    d. 85.7 kΩ

Chapter 6: Series-Parallel Circuits

15. See figure 6-2. If all the resistors are 4.7 kΩ, and source voltage is 20 V, find I_{R2}.
a. 12.53 mA
b. 0.53 mA
c. 11.99 mA
d. 1.06 mA

16. See figure 6-1. If R_3 opens, V_{R1} will
a. increase
b. decrease
c. remain the same
d. decrease to zero.

17. See figure 6-2. If R_1 opens, V_{R2} will
a. increase
b. decrease
c. remain the same
d. cause the fuse to blow

18. See figure 6-2. If R_5 shorts, V_{R2} will
a. increase
b. decrease
c. remain the same
d. decrease to zero

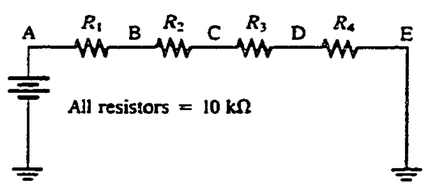


Figure 6-3

19. See figure 6-3. The resistance between points B and E
a. 10 kΩ
b. 20 kΩ
c. 30 kΩ
d. 40 kΩ

20. See figure 6-3. If V_4 = 10 V, find V_{AD}.
a. 10 V
b. 20 V
c. 30 V
d. 40 V

Chapter 6: Series-Parallel Circuits

21. See figure 6-3. If V_S = 22 V, find V_{DB}.
    a. 5.5 V
    b. 22 V
    c. 16.5 V
    d. -11.5 V

22. See figure 6-3. If V_S = 12 V and R_3 shorts, find V_{EB}.
    a. -3 V
    b. -8 V
    c. 6 V
    d. 8 V

23. See figure 6-3. If another 10 kΩ resistor were placed in parallel with R_4, V_{R4} will
    a. increase
    b. decrease
    c. remain the same
    d. change to 4 volts

24. See figure 6-1. V_S = 20 V, R_1 = 10 kΩ, R_2 = 50 kΩ, and R_3 = 15 kΩ. Find P_2.
    a. 2.29 mW
    b. 7.64 mW
    c. 8.63 mW
    d. 18.6 mW

25. See figure 6-2. If R_3 shorts, V_{R5} will
    a. increase
    b. decrease
    c. remain the same
    d. equal V_{R1}

26. See figure 6-1. Resistor R_1 is connected
    a. in series with R_2.
    b. in series with R_3.
    c. in parallel with R_2.
    d. in parallel with R_3.
    e. none of these

27. See figure 6-2. R_2 and R_5 are connected
    a. in series with each other and in parallel with R_3.
    b. in parallel.
    c. in series with R_1.
    d. in series with R_3.

28. See figure 6-1. If R_1 = 4.7 kΩ, R_2 = 3300 Ω and R_3 = 1000 Ω, the total resistance of the circuit is
    a. 5700 Ω
    b. 5467 Ω
    c. 4125 Ω
    d. 660 Ω

Chapter 6: Series-Parallel Circuits

29. See figure 6-1. If R_1 = 4.7 kΩ, R_2 = 3300 Ω, R_3 = 1000 Ω, and the source voltage is 50 V, calculate the total current.
a. 8.8 mA
b. 9.15 mA
c. 12.1 mA
d. 75.7 mA

30. If a combination of four parallel 10 kΩ resistors were in series with a single 20 kΩ resistor, and one of the parallel combination resistors opened, the voltage across the other parallel resistors would
a. increase.
b. decrease.
c. remain the same.

31. Two 1 kΩ resistors are in series and this series combination is in parallel with a 2.2 kΩ resistor. The voltage across one of the 1 kΩ resistors is 6 V. The voltage across the 2.2 kΩ resistor is
a. 6 V
b. 3 V
c. 12 V
d. 13.2 V

32. The parallel combination of a 330 Ω resistor and a 470 Ω resistor is in series with the parallel combination of four 1 kΩ resistors. A 100 V source is connected across the circuit. The resistor with the most current has a value of
a. 1 kΩ
b. 330 Ω
c. 470 Ω

33. The parallel combination of a 330 Ω resistor and a 470 Ω resistor is in series with the parallel combination of four 1 kΩ resistors. A 100 V source is connected across the circuit. The resistor with the most voltage across it has a value of
a. 1 kΩ
b. 330 Ω
c. 470 Ω

34. A certain voltage divider consists of two 10 kΩ resistors in series. Which of the following load resistors will have the most effect on the output voltage?
a. 1 MΩ
b. 20 kΩ
c. 100 kΩ
d. 10 kΩ

Chapter 6: Series-Parallel Circuits

35. In a certain two-source circuit, one source acting alone produces 10 mA through a given branch. The other source acting alone produces 8 mA in the opposite direction through the same branch. The total current through the branch is
    a. 10 mA
    b. 8 mA
    c. 18 mA
    d. 2 mA

Chapter 8: Introduction to Alternating Current and Voltage.

1. The frequency of a sine wave is the reciprocal of the period.
   a. true
   b. false

2. The higher the frequency of a sine wave, the shorter the period.
   a. true
   b. false

3. The peak value of a sine wave is smaller than the rms value.
   a. true
   b. false

4. If an ac voltage is applied to a resistor, the current is inversely proportional to the voltage.
   a. true
   b. false

5. Sine, square, dc, and triangle waves are all forms of ac.
   a. true
   b. false

6. The peak value of a sine wave is smaller in value than the rms value.
   a. true
   b. false

7. The following is a correct formula. $V_{p-p} = 1.414 \times V_{rms}$
   a. true
   b. false

8. The term rms means root mean square.
   a. true
   b. false

9. If an ac voltage is applied to a resistor the current will increase.
   a. true
   b. false

10. Commercial line voltages are usually square waves at a frequency of 60 Hz.
    a. true
    b. false

11. A formula for V_{p-p} is
    a. 0.707 V_{rms}
    b. 0.707 V_p
    c. 2 V_p
    d. 2.8 V_p

Chapter 8: Introduction to Alternating Current and Voltage

12. The rms value of a sine wave means
    a. the same as $I_{p-p}R$
    b. the root mean square value.
    c. the heating effect of an ac generator of the same voltage.
    d. the same as I_p^2R

13. A sine wave has a peak value of 230 V. What is the instantaneous value at an angle of 42°?
    a. 76.09 V
    b. 115 V
    c. 149 V
    d. 153.9 V

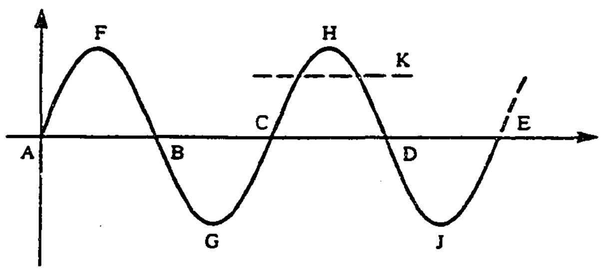


Figure 8-1

14. See figure 8-1. The value at point K is
    a. the period.
    b. the rms voltage.
    c. the p-p voltage.
    d. V_p.

15. See figure 8-1. The time from points G to J is called
    a. the frequency.
    b. V_p.
    c. the period.
    d. the rms voltage.

16. See figure 8-1. V_{p-p} would be measured from points
    a. A to F.
    b. K to J.
    c. B to D.
    d. G to H.

Chapter 8: Introduction to Alternating Current and Voltage

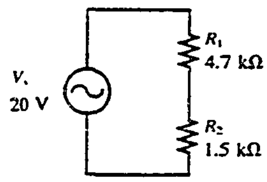


Figure 8-2

17. See figure 8-2. Find V_{R2}.
    a. 6.84 V_{p-p}
    b. 13.15 V_p
    c. 6.84 V_p
    d. 4.83 V_p

18. See figure 8-2. Find V_S.
    a. 14.14 V_p
    b. 56.6 V_{p-p}
    c. 20 V_{p-p}
    d. 28.28 V_{p-p}

19. The length of time for an ac wave form to start to repeat is called
    a. the frequency.
    b. alternating current.
    c. revolutions per minute.
    d. the period.

20. See figure 8-2. Solve for V_{R1p}.
    a. 21.44 V_p
    b. 6.84 V_p
    c. 13.15 V_p
    d. 13.68 V_p

21. A sine wave has a value of 22 V_{p-p}. What is the instantaneous value at an angle of 284°?
    a. 10.67 V
    b. 0.33 V
    c. −10.67 V
    d. −2.66 V

22. See figure 8-2. If R_1 opens, V_{R2} will
    a. increase.
    b. decrease.
    c. remain the same.
    d. not change since this is an ac source.

23. See figure 8-2 Find the instantaneous voltage across R_1 at an angle of 22°.
a. 8.03 V
b. 11.96 V
c. 2.56 V
d. 20.25 V

24. A square wave has a pulse width of 0.050 ms and a frequency of 4 kHz. Find the duty cycle of the square wave.
a. 80 %
b. 20 %
c. 1.25 %
d. 98.75 %

25. A square wave has a peak value of 10 V. It changes from 1 V to 9 V in 0.050 ms. This is called
a. fall time.
b. average value.
c. pulse width.
d. rise time.

26. A sine wave has a peak value of 169 V. What is the instantaneous value at an angle of 37°?
a. 135 V
b. 119 V
c. 239 V
d. 102 V

27. See figure 8-1. The time from point B to C is called
a. an alternation.
b. the period.
c. a cycle.
d. peak voltage.

28. See figure 8-1. The voltage value at point H represents
a. rms voltage.
b. peak voltage.
c. p-p voltage.
d. one cycle of voltage.

29. See figure 8-2. Find V_{R1}.
a. 15.16 V_{p-p}
b. 21.43 V_{peak}
c. 42.88 V_{peak}
d. 15.16 V_{peak}

30. See figure 8-2. Calculate I_{p-p}.
a. 4.55 mA
b. 3.22 mA
c. 9.12 mA
d. 6..44 mA

Chapter 8: Introduction to Alternating Current and Voltage

31. When a sine wave has a frequency of 60 Hz, in 10 s it goes through
    a. 6 cycles
    b. 10 cycles
    c. 1/16 cycles
    d. 600 cycles

32. If the peak value of a sine wave is 10 V, the peak-to-peak value is
    a. 20 V
    b. 5 V
    c. 100 V
    d. none of these

33. The instantaneous value of a 15 A peak sine wave at a point 32 degrees from its positive-going zero crossing is
    a. 7.95 A
    b. 7.5 A
    c. 2.13 A
    d. ~~7.95 A~~ → 7.0095A

34. If the rms current through a 10 kΩ resistor is 5 mA, the rms voltage drop across the resistor is
    a. 70.7 V
    b. 7.07 V
    c. 5 V
    d. 50 V

35. Two series resistors are connected to an ac source. If there is 6.5 V rms across one resistor and 3.2 V across the other, the peak source voltage is
    a. 9.7 V
    b. 9.19 V
    c. 13.72
    d. 4.53 V

Chapter 9: Capacitors

1. The measure of a capacitor's ability to store voltage is called capacitance.
   a. true
   b. false

2. A capacitor blocks dc and passes ac.
   a. true
   b. false

3. If two capacitors are in parallel across a dc source, the smaller capacitor has the larger voltage across it.
   a. true
   b. false

4. If the distance between the plates of a capacitor is increased, the capacitance decreases.
   a. true
   b. false

5. The time constant is the time required for a capacitor to fully charge.
   a. true
   b. false

6. The measure of a capacitor's ability to store resistance is called capacitance.
   a. true
   b. false

7. If two capacitors are in series across a dc source, the smallest capacitor has the largest voltage across it.
   a. true
   b. false

8. A capacitor will fully charge in about five time constants.
   a. true
   b. false

9. To find the total capacitance of two capacitors in parallel, you must combine them using a similar procedure as resistors in parallel.
   a. true
   b. false

10. If the area of the plates of a capacitor is decreased, then the capacitance will decrease.
    a. true
    b. false

Chapter 9: Capacitors

11. A capacitor has a charge of 0.500 μC and a voltage of 50 V across it. What is the capacitance?
a. 0.01 μF
b. 1 μF
c. 0.001 μF
d. ~~0.01 μF~~ .0001 pF

12. A 0.022 μF capacitor has a voltage of 22 V across it. What charge is stored on the capacitor?
a. 0.0484 μC
b. 4.84 μC
c. 0.484 μC
d. 48.4 μC

13. The dc working voltage of a capacitor is 100 V. This means that the dielectric must be able to withstand
a. 100 V dc.
b. 75 V_{rms}
c. 220 V_{p-p}
d. 85 V_{rms}

14. Two capacitors are connected in parallel across 20 V. If C_1 = 0.050 μF and C_2 = 0.100 μF, what are C_T and the voltage across each capacitor?
a. 0.15 μF and 10 V
b. 0.05 μF and 15 V
c. 0.10 μF and 20 V
d. 0.15 μF and 20 V

15. Three capacitors are in series. C_1 = 0.022 μF, C_2 = 0.022 μF, and C_3 = 0.050 μF. The source voltage is 25 V. What is the voltage across C_3?
a. 10.24 V
b. 11.76 V
c. 4.5 V
d. 17.5 V

16. A 4.7 μF is in series with a 22 kΩ resistor. What is the time constant?
a. 0.103 ms
b. 1.03 ms
c. 10.3 ms
d. 103 ms

17. A 0.047 μF capacitor is in series with a 100 kΩ resistor across a 20 V source. How long will it take for the capacitor to completely charge?
a. 2.35 s
b. 0.235 ms
c. 23.5 ms
d. 235 ms

Chapter 9: Capacitors

18. A 1.0 μF capacitor is in series with a 47 kΩ resistor. The voltage across the capacitor is 25 V. How long will it take to completely discharge the capacitor through the resistor?
a. 47 s
b. 235 s
c. 47 ms
d. 235 ms

19. A 1 μF capacitor is in series with a 10 kΩ resistor. A switch is closed applying 20 V to the circuit. What will the voltage across the capacitor be after one time constant?
a. 17 V
b. 12.06 V
c. 10.99 V
d. 12.64 V

20. A 4.7 μF capacitor is in series with a 10 kΩ resistor. A switch is closed, applying 25 V to the circuit. What will the voltage across the resistor be after one time constant?
a. 9.2 V
b. 23.75 V
c. 21.63 V
d. 15.8 V

21. A 4.7 μF is in a circuit with a frequency of 10 kHz. What value is X_c?
a. 338.8 Ω
b. 294 μΩ
c. 3.388 Ω
d. infinite

22. A 2000 pF capacitor has an X_c of 745 Ω. What is the operating frequency?
a. 106.8 Hz
b. 10.14 kHz
c. 1.014 kHz
d. 1014 Hz

23. An ohmmeter is used to test a capacitor. The reading in both directions is very high. The capacitor is probably
a. shorted.
b. leaking.
c. open.
d. completely charged.

24. A 22 μF capacitor is connected to a 15 V, 400 Hz source. The current will be
a. 55 mA
b. 18.1 mA
c. 829 mA
d. 1.81 A

Chapter 9: Capacitors

25. You want to check a large electrolytic capacitor with an ohmmeter. You place the leads across the capacitor and the meter reading starts at a low value and keeps increasing. The capacitor is
a. open.
b. leaky.
c. shorted.
d. OK; this is normal.

26. Three capacitors are in series. C_1 = 0.100 μF, C_2 = 0.100 μF, and C_3 = 0.050 μF. The source voltage is 75 V. What is the voltage across C_3?
a. 18.75 V
b. 50 V
c. 37.5 V
d. 100 V

27. A 0.047 μF capacitor is in series with a 1 MΩ resistor. How long will it take to completely charge the capacitor? The supply voltage is 50 V.
a. 0.047 s
b. 0.029 s
c. 0.235 s
d. 0.47 s

28. A 0.1 μF capacitor is in series with a 2.2 kΩ resistor. A voltage of 30 V is applied when the switch is closed. What will the voltage across the capacitor be after one time constant?
a. 29.4 V
b. 28.50 V
c. 25.95 V
d. 18.96 V

29. If the frequency applied to a capacitor is increased, the capacitive reactance will
a. increase.
b. decrease.
c. remain the same.
d. vary up and down.

30. A capacitor which will transfer an ac signal from one stage to another is called a__________capacitor.
a. bypass
b. filter
c. coupling
d. transfer

Chapter 9: Capacitors

31. A 1 μF, a 2.2 μF, and a 0.05 μF capacitor are connected in series. The total capacitance is less than
a. 1 μF
b. 2.2 μF
c. 0.05 μF
d. 0.001 μF

32. Four 0.022 μF capacitors are in parallel. The total capacitance is
a. 0.02 μF
b. 0.08 μF
c. 0.05 μF
d. 0.04 μF

33. An uncharged capacitor and a resistor are connected in series with a switch and a 12 V battery. At the instant the switch is closed, the voltage across the capacitor is
a. 12 V
b. 6 V
c. 24 V
d. 0 V

34. An uncharged capacitor and a resistor are connected in series with a switch and a 12 V battery. The voltage across the capacitor when it is fully charged is
a. 12 V
b. 6 V
c. 24 V
d. −6 V

35. An uncharged capacitor and a resistor are connected in series with a switch and a 12 V battery. The capacitor will reach full charge in a time equal to approximately
a. RC
b. 5 RC
c. 12 RC
d. cannot be predicted

Chapter 10: Inductors

1. The total inductance of inductors in parallel is the sum of all the inductances.
   a. true
   b. false

2. The energy stored in an inductor's electromagnetic field is produced by the current.
   a. true
   b. false

3. An inductor passes dc and opposes ac.
   a. true
   b. false

4. Inductive reactance decreases when the frequency is increased.
   a. true
   b. false

5. In an inductive circuit the voltage leads the current.
   a. true
   b. false

6. The energy stored in an inductor's electromagnetic field is produced by the resistance of the winding.
   a. true
   b. false

7. In an inductive circuit the voltage and current are in phase.
   a. true
   b. false

8. Inductances in series or parallel combine in a similar manner to resistors in series or parallel.
   a. true
   b. false

9. When a dc voltage is first applied to an inductor, the circuit current is zero.
   a. true
   b. false

10. If an inductor is placed in a circuit with ac applied, the voltage across the inductor leads the current through it.
    a. true
    b. false

11. A 50 mH inductor is in series with a 15 mH inductor. What is the total inductance?
    a. 11.5 mH
    b. 15 mH
    c. 50 mH
    d. 65 mH

Chapter 10: Inductors

12. A 12 mH inductor is in series with a 10 kΩ resistor. The source voltage is 15 V. What is the maximum current?
a. 1.2 mA
b. 1.5 mA
c. 2.2 mA
d. 6.32 mA

13. An inductor has an ac current flowing through it. The magnetic field is
a. steady.
b. constantly changing.
c. moving from south to north.
d. collapsed.

14. You have two inductors. One inductor has an iron core, and the other inductor has an air core. Which inductor probably has the larger inductance?
a. air core
b. neither; both have the same
c. iron core
d. there is no way to tell

15. A 50 mH inductor has a voltage of 25 V with a frequency of 22 kHz applied to it. What is X_L?
a. 6908 Ω
b. 500 Ω
c. 113 Ω
d. 69 Ω

16. In an inductive circuit, the__________lags the__________.
a. voltage, resistance
b. current, voltage
c. current, resistance
d. voltage, reactance

17. A 27 mH inductor has an X_L of 5.5 kΩ. What is the applied frequency?
a. 932 Hz
b. 324 Hz
c. 3.24 kHz
d. 32.4 kHz

18. A 10 mH inductor is in series with a 47 kΩ resistor. What is the time constant?
a. 0.213 µs
b. 470 s
c. 213 s
d. 470 ms

Chapter 10: Inductors

19. An inductor has a magnetic field around it. How many time constants will it take to collapse the field completely?
 a. 1
 b. 3
 c. 4
 d. 5

20. An inductor with an inductance of 0.2 mH and a resistance of 20 Ω is applied to a 1 MHz source. What is the inductive reactance?
 a. 1.256 MΩ
 b. 125.6 kΩ
 c. 1.256 kΩ
 d. 125.6 Ω

21. An inductor is in an ac circuit with a voltage of 12 V. The current is 50 mA. What is X_L?
 a. 6 Ω
 b. 60 Ω
 c. 600 Ω
 d. 240 Ω

22. You believe you have a faulty inductor. The resistance measures infinite. The dc voltage across the coil equals the source voltage. The probable fault, if any, is that
 a. the coil is shorted.
 b. the coil is open.
 c. the coil is normal.
 d. the coil will work on ac.

23. A 20 mH inductor is in parallel with a 50 mH inductor. The total inductance is
 a. 20 mH
 b. 50 mH
 c. 70 mH
 d. 14.29 mH

24. You have an application that will use an inductance of 65 mH. You have one inductor with a value of 100 mH. What value must the other inductor have to equal the desired total value? How will the circuit be connected?
 a. 185.7 mH, in series
 b. 185.7 mH, in parallel
 c. 35 mH, in parallel
 d. 35 mH, in series

25. A coil of wire is carrying a dc current of 100 mA. The X_L of the coil is 600 Ω at 60 Hz. The voltage across the coil is 30 V. What is the resistance of the coil?
 a. 600 Ω
 b. 60 Ω
 c. 300 Ω
 d. 30 Ω

Chapter 10: Inductors

26. Two 2.5 mH inductors are in series with a 4.7 kΩ resistor. The source voltage is 100 V. What is the maximum current in this circuit?
a. 21.3 mA
b. 63.2 mA
c. 1.1 mA
d. 7.9 mA

27. A frequency of 10 kHz is applied to a coil with an inductance of 150 mH. What is the inductance reactance?
a. 1500 Ω
b. 6280 Ω
c. 8450 Ω
d. 9420 Ω

28. A 50 mH inductor is in series with a 5 kΩ resistor. What is the time constant?
a. 10 μs
b. 100 s
c. 250 s
d. 10 ms

29. A 40 mH inductor is in parallel with a 24 mH inductor. The total inductance is
a. 64 mH.
b. 32 mH.
c. 15 mH.
d. 150 mH.

30. You think that an inductor is faulty. You measure the resistance at zero ohms. The dc voltage across the coil measures zero. The probable fault, if any, is
a. the coil is shorted.
b. the coil is open.
c. the coil is normal.
d. the coil will work on ac.

31. An inductance of 0.05 μH is larger than
a. 0.0000005 H
b. 0.000005 H
c. 0.000000008 H
d. 0.00005 H

32. An inductance of 0.33 mH is smaller than
a. 33 μH
b. 330 μH
c. 0.05 mH
d. 0.0005 H

Chapter 10: Inductors

33. Four 10 mH inductors are in series. The total inductance is
  a. 40 mH
  b. 2.5 mH
  c. 40,000 µH
  d. both a and c

34. A 1 mH, a 3.3 mH, and a 0.1 mH inductor are connected in parallel. The total inductance is
  a. 4.4 mH
  b. greater than 3.3 mH
  c. less than 0.1 mH
  d. both a and b

35. An inductor, a resistor, and a switch are connected in series to a 12 V battery. At the instant the switch is closed, the inductor voltage is
  a. 0 V
  b. 12 V
  c. 6 V
  d. 4 V

Chapter 11: Transformers

1. Only the number of turns in the primary and secondary of a transformer determines the actual secondary voltage.
   a. true
   b. false

2. A transformer can be used as an impedance matching device.
   a. true
   b. false

3. A step-down transformer could have a primary-secondary turns ratio of 4:1.
   a. true
   b. false

4. Transformer cores are made from laminated iron to reduce losses.
   a. true
   b. false

5. The efficiency of transformers is very low.
   a. true
   b. false

6. A transformer with a turns ratio of 1:1 is often used to isolate a load from a source.
   a. true
   b. false

7. A transformer with a turns ratio of 1:7 is a step down transformer.
   a. true
   b. false

8. If a dc voltage is applied to the primary of a transformer, an ac voltage is induced in the secondary.
   a. true
   b. false

9. An ideal transformer has no power loss.
   a. true
   b. false

10. A typical transformer fault would be an open winding.
    a. true
    b. false

11. A step-up transformer will decrease__________ and increase __________
    a. current, resistance
    b. current, voltage
    c. voltage, current
    d. resistance, current

Chapter 11: Transformers

12. The hysteresis loss in a transformer is
    a. due to current flowing in the core.
    b. caused by rapid reversal of the magnetic field.
    c. caused by the resistance of the wire.
    d. another name for flux leakage loss.

13. Eddy current loss in a transformer is
    a. due to current flowing in the core.
    b. caused by rapid reversal of the magnetic field.
    c. caused by the resistance of the wire.
    d. another name for flux leakage loss.

14. When a source is connected to a load, maximum power is delivered to the load when the load resistance is equal to the source resistance. This is a definition of
    a. Lenz's Law.
    b. Ohm's Law.
    c. Maximum power transfer theorem.
    d. Kirchhoff's Law.

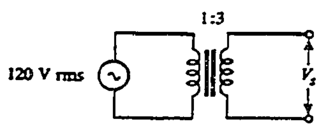


Figure 11- 1

15. See figure 11-1. There are three times as many turns in the secondary as in the primary. What is the secondary voltage V_s?
    a. 40
    b. 80 V
    c. 240 V
    d. 360 V

16. See figure 11-1. If the ratio of primary to secondary turns were changed to 7:1, what is the output voltage V_s?
    a. 17.14 V
    b. 840 V
    c. 8.59 V
    d. 420 V

17. See figure 11-1. If the primary to secondary turns ratio is changed to 3:1, and a load resistor of 100 Ω is in the secondary, what is the secondary current I_s?
    a. 33 mA
    b. 40 mA
    c. 330 mA
    d. 400 mA

Chapter 11: Transformers

18. See figure 11-1. The primary-secondary turns ratio is kept at 1:3 and I_S is 240 mA. What is the primary current I_P?
a. 60 mA
b. 120 mA
c. 720 mA
d. 1.2 A

19. See figure 11-1. The primary-secondary turns ratio is 3:1 and I_S is 240 mA. What is the reflected resistance seen by the primary?
a. 167 Ω
b. 500 Ω
c. 1500 Ω
d. 9000 Ω

20. A circuit is giving you problems. The power transformer is delivering a low output voltage. The input voltage to the transformer is correct. A probable trouble is
a. an open secondary.
b. a shorted primary.
c. an open primary.
d. a partially shorted secondary.

21. You are going to buy a matching transformer to match a 600 Ω audio signal distribution line to an 8 Ω speaker. The primary should have__________ more turns than the secondary.
a. 8.66
b. 75
c. 0.013
d. 0.115

22. You need to couple two circuits together with no change in either voltage or current. The correct transformer to use would be
a. a step-up type.
b. an isolation type.
c. a step-down type.
d. a power type.

23. A common use for a transformer is to
a. convert a lower current into a higher current.
b. convert a higher voltage into a lower voltage.
c. match the impedance of a source to the impedance of a load.
d. all of these
e. none of these

Chapter 11: Transformers

24. A power transformer for a TV set has a primary winding designed to operate with an ac voltage of 125 V. This transformer has four secondary windings, all of the same gage wire. You measure the resistance of each secondary winding and find that one has the lowest resistance. Which winding will have the lowest resistance?
    a. the 550 V secondary
    b. the 6.3 V secondary
    c. the 12 V secondary
    d. the 5 V secondary

25. The center tapped secondary winding of a transformer gives unequal voltages on each half of the secondary. This is causing your power amplifier to work improperly. What is a probable solution?
    a. Add some turns to the half with the lower voltage winding.
    b. Remove some turns from the half with the higher voltage winding.
    c. Replace the transformer.
    d. Do not concern yourself; the customer will probably not notice the problem.

26. A step-up transformer will increase__________ and decrease__________.
    a. voltage, impedance
    b. current, impedance
    c. voltage, power
    d. power, current

27. See figure 11-1. If the ratio of primary to secondary turns is changed to 4.5:1, what is the output voltage V_S?
    a. 540 V
    b. 26.67 V
    c. 5.92 V
    d. 4.72 V

28. See figure 11-1. If the primary to secondary turns ratio is changed to 4:1, and a load resistor of 50 ohms is in the secondary, what is the secondary current?
    a. 1.66 A
    b. 600 mA
    c. 9.6 A
    d. 4.8 A

29. See figure 11-1. The primary-secondary turns ratio is changed to 4:1 and I_S = 40 mA. What is the primary current?
    a. 160 mA
    b. 40 mA
    c. 10 mA
    d. 4 mA

Chapter 11: Transformers

30. See figure 11-1. The primary-secondary turns ratio is changed to 4:1 and I_s = 40 mA. What is the reflected resistance seen by the primary?
    a. 4 kΩ
    b. 8 kΩ
    c. 12 kΩ
    d. 16 kΩ

31. When the turns ratio of a transformer is 1:10 and the primary ac voltage is 6 V, the secondary voltage is
    a. 60 V
    b. 0.6 V
    c. 6 V
    d. 36 V

32. If 10 W of power are applied to the primary of an ideal transformer with a turns ratio of 1:5, the power delivered to the secondary load is
    a. 50 W
    b. 0.5 W
    c. 0 W
    d. 10 W

33. When a 1 kΩ load resistor is connected across the secondary winding of a transformer with a turns ratio of 1:2, the source "sees" a reflected load of
    a. 250 Ω
    b. 2 kΩ
    c. 4 kΩ
    d. 1 kΩ

34. When a 1 kΩ load resistor is connected across the secondary winding of a transformer with a turns ratio of 2:1, the source "sees" a reflected load of
    a. 1 kΩ
    b. 2 kΩ
    c. 4 kΩ
    d. 500 Ω

35. The turns ratio required to match a 50 Ω source to a 200 Ω load is
    a. 4:1
    b. 2:1
    c. 1:4
    d. 1:2

Chapter 12: Frequency Response of RC Circuits

1. The total current in an RC circuit always leads the source voltage.
   a. true
   b. false

2. The phasor combination of V_R and V_C in an RC series circuit is called the source voltage, V_S.
   a. true
   b. false

3. An RC circuit can be used as a filter to eliminate certain frequencies.
   a. true
   b. false

4. As the frequency applied to an RC circuit is decreased, the phase angle decreases.
   a. true
   b. false

5. As the frequency applied to an RC circuit is varied, X_C and resistance also vary.
   a. true
   b. false

6. The total current in an RC circuit always lags the source voltage.
   a. true
   b. false

7. The phasor combination of X_C and R is called Z.
   a. true
   b. false

8. As the frequency applied to an RC circuit is increased, the impedance decreases.
   a. true
   b. false

9. The phase angle of an RC circuit varies inversely with frequency.
   a. true
   b. false

10. When the frequency applied to an RC circuit is varied, the value of X_C varies.
    a. true
    b. false

Chapter 12: Frequency Response of RC Circuits

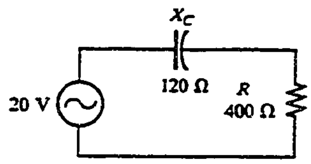


Figure 12-1

11. See figure 12-1. If the frequency is 60 Hz, what is the value of capacitance?
    a. 22 µF
    b. 44 µF
    c. 66 µF
    d. 88 µF

12. See figure 12-1. If the source voltage is changed to 50 V, find the impedance.
    a. 120 Ω
    b. 280 Ω
    c. 418 Ω
    d. 520 Ω

13. See figure 12-1. If the source voltage is changed to 50 V, calculate the true power.
    a. 916 mW
    b. 5.72 mW
    c. 5.72 W
    d. 275 mW

14. See figure 12-1. If the operating frequency is increased, what effect will that increase have on the current?
    a. It will increase.
    b. It will remain the same.
    c. It will decrease.
    d. It will decrease to zero.

15. See figure 12-1. If the operating frequency is increased, what effect will that increase have upon the phase angle?
    a. It will increase.
    b. It will remain the same.
    c. It will decrease.
    d. It will change to another quadrant.

Chapter 12: Frequency Response of RC Circuits

16. See figure 12-1. If the operating frequency is increased, what effect will it have on the value of the resistor?
    a. It will increase.
    b. It will remain the same.
    c. It will decrease.
    d. It will open.

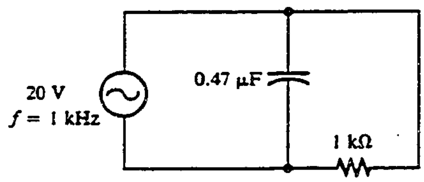


Figure 12-2

17. See figure 12-2. If the resistor is changed to 47 kΩ, what effect will that change have upon the total current?
    a. It will increase.
    b. It will remain the same.
    c. It will decrease.
    d. It will decrease to zero.

18. See figure 12-2. Calculate the voltage drop across the resistor.
    a. 10 V
    b. 20 V
    c. 59 mV
    d. 19.94 V

19. See figure 12-2. You need to increase the power factor. What changes could you make to accomplish this?
    a. Increase the value of Vs.
    b. Increase the value of the resistor.
    c. Increase the value of the capacitor.
    d. Decrease the value of the capacitor.

20. See figure 12-2. Which statement describes the relationship of I_C to I_R?
    a. They are in phase.
    b. IC leads IR.
    c. IC lags IR.
    d. They are 180° out of phase.

Chapter 12: Frequency Response of RC Circuits

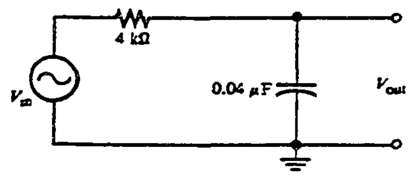


Figure 12-3

21. See figure 12-3. This circuit is known as
a. a high-pass filter.
b. a band-pass filter.
c. a low-pass filter.
d. parallel RC circuit.

22. See figure 12-3. If the resistor is changed to 47 kΩ, what is the new cutoff frequency?
a. 85 Hz
b. 118 Hz
c. 995 Hz
d. 1012 Hz

23. See figure 12-3. If the input voltage were constant at 22 V for all incoming frequencies, what would the output voltage be at the cutoff frequency?
a. 6.446 V
b. 31.12 V
c. 15.554 V
d. 22 V

24. See figure 12-3. If the output were taken across the resistor, the circuit would be known as a __________filter.
a. low-pass
b. high-pass
c. band-pass
d. band-notch

25. See figure 12-3. This filter has an output voltage that is too high at the cutoff frequency. Determine a possible trouble that could cause this output.
a. The resistor has opened.
b. The capacitor has shorted.
c. The resistor has shorted.
d. The capacitor has become leaky.

26. See figure 12-1. Calculate the voltage drop across the capacitor.
a. 19.14 V
b. 16.7 V
c. 20 V
d. 5.75 V

Chapter 12: Frequency Response of RC Circuits

27. See figure 12-1. Calculate the apparent power.
a. 0.874 VA
b. 0.916 VA
c. 0.957 VA
d. 0.989 VA

28. See figure 12-2. Find the total impedance.
a. 1000 Ω
b. 880 Ω
c. 321 Ω
d. 62 Ω

29. See figure 12-1. If the frequency is increased, the phase angle will__________ and the impedance will __________.
a. decrease, increase
b. decrease, decrease
c. increase, decrease
d. increase, increase

30. See figure 12-3. The cutoff frequency is
a. 6250 Hz.
b. 99 Hz.
c. 480 Hz.
d. 995 Hz.

31. In a series RC circuit, 10 V_{rms} is measured across the resistor and 10 V_{rms} is also measured across the capacitor. The rms source voltage is
a. 20 V
b. 14.14 V
c. 28.28 V
d. 10 V

32. In a parallel RC circuit, there is 1 A_{rms} through the resistive branch and 1 A_{rms} through the capacitive branch. The total rms current is
a. 1 A
b. 2 A
c. 2.28 A
d. 1.414 A

33. A power factor of 1 indicates that the circuit phase angle is
a. 90°
b. 45°
c. 180°
d. 0°

34. For a certain load, the true power is 100 W and the reactive power is 100 VAR. The apparent power is
a. 200 VA
b. 100 VA
c. 141.4 VA
d. 141.4 W

Chapter 12: Frequency Response of RC Circuits

35. If the bandwidth of a certain low-pass is 1 kHz, the cutoff frequency is
    a. 0 Hz
    b. 500 Hz
    c. 2 kHz
    d. 1000 Hz

Chapter 13 : Frequency Response of RL Circuits

1. The source voltage always leads the total current in an RL circuit.
   a. true
   b. false

2. A low-pass filter passes high frequencies and blocks other frequencies.
   a. true
   b. false

3. The impedance of an RL series circuit varies inversely with the frequency.
   a. true
   b. false

4. In a filter circuit using RL components, a decrease in the value of R will increase the cutoff frequency.
   a. true
   b. false

5. The impedance of a series RL circuit is found by adding the values of X_L and R.
   a. true
   b. false

6. The source voltage always lags the total current in an RL circuit.
   a. true
   b. false

7. A high-pass filter passes high frequencies and blocks low frequencies.
   a. true
   b. false

8. In an RL circuit, if the frequency is increased, the impedance will decrease.
   a. true
   b. false

9. In a filter circuit using RL components, an increase in the value of inductance will increase the cutoff frequency.
   a. true
   b. false

10. The impedance if a series RL circuit is found by adding the values of X_L and R using a phasor diagram.
    a. true
    b. false

Chapter 13 : Frequency Response of RL Circuits

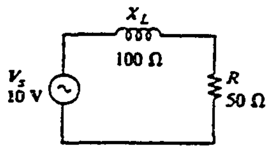


Figure 13- 1

11. See figure 13-1. If the frequency is 60 Hz, what is the value of the inductance?
    a. 265 mH
    b. 3.768 H
    c. 26.5 mH
    d. 3.768 mH

12. See figure 13-1. If the source voltage is changed to 50 V, find the impedance.
    a. 104 Ω
    b. 112 Ω
    c. 1120 Ω
    d. 1040 Ω

13. See figure 13-1. If the source voltage is changed to 50 V, calculate the true power.
    a. 1 W
    b. 400 mW
    c. 4 W
    d. 10 W

14. See figure 13-1. If the operating frequency is increased, the current will
    a. increase.
    b. decrease.
    c. remain the same.
    d. decrease to zero.

15. See figure 13-1. If the operating frequency is increased, the phase angle will
    a. increase.
    b. decrease
    c. remain the same.
    d. change to another quadrant.

16. See figure 13-1. If the operating frequency is increased, the value of inductance will
    a. increase.
    b. decrease
    c. remain the same.
    d. decrease to zero.

Chapter 13 : Frequency Response of RL Circuits

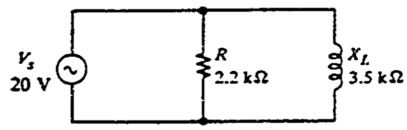


Figure 13-2

17. See figure 13-2. If the value of the resistor is changed to 47 kΩ, the total current will
a. increase.
b. decrease.
c. remain the same.
d. decrease to zero.

18. See figure 13-2. You need to increase the power factor. What change could you make to accomplish this?
a. Increase the source voltage.
b. Decrease the source voltage.
c. Decrease the value of the resistor.
d. Increase the value of the resistor.

19. See figure 13-2. Which statement describes the relationship of I_L to I_R?
a. They are in phase.
b. I_L leads I_R.
c. I_L lags I_R.
d. They are 180° out of phase.

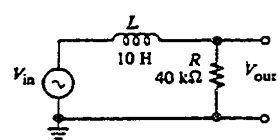


Figure 13-3

20. See figure 13-3. This circuit is known as a ________ filter.
a. low-pass
b. high-pass
c. band-pass
d. notch

21. See figure 13-3. If the resistor is changed to 50 kΩ, find the new cutoff frequency.
a. 637 Hz
b. 796 Hz
c. 637 kHz
d. 7.96 kHz

Chapter 13 : Frequency Response of RL Circuits

22. See figure 13-3. If the input voltage is constant at 47 V for all frequencies, find V_{out} at the cutoff frequency.
a. 6.77 V
b. 33.3 V
c. 29.7 V
d. 17.3 V

23. See figure 13-3. Some of the turns of the inductor have shorted. What effect will this have on the circuit operation?
a. The cutoff frequency will increase.
b. The cutoff frequency will decrease.
c. The output voltage at the cutoff frequency will increase.
d. The output voltage at the cutoff frequency will decrease.

24. See figure 13-1. If the frequency decreases, the phase angle will__________, and the current will __________.
a. increase, increase
b. decrease, decrease
c. increase, decrease
d. decrease, increase

25. See figure 13-3. If the output were taken across the inductor, the circuit would be known as a __________ filter.
a. low-pass
b. high-pass
c. band-pass
d. notch

26. See figure 13-1. Find the voltage across the inductor.
a. 0.4 V
b. 0.894 V
c. 4.47 V
d. 8.94 V

27. See figure 13-1. Find the apparent power.
a. 0.4 VA
b. 0.8 VA
c. 8.94 VA
d. 0.894 VA

28. See figure 13-2. Find the total impedance.
a. 1.074 kΩ
b. 9.09 kΩ
c. 5.71 kΩ
d. 1.86 kΩ

29. See figure 13-1. If the frequency is increased, the phase angle will __________ and the impedance will __________
a. decrease, increase
b. decrease, decrease
c. increase, decrease
d. increase, increase

Chapter 13 : Frequency Response of RL Circuits

30. See figure 13-3. Find the cutoff frequency.
    a. 2.5 MHz
    b. 637 Hz
    c. 1.2 MHz
    d. 408 Hz

31. In a series RL circuit, 10 V_{rms} is measured across the resistor, and 10 V_{rms} is measured across the inductor. The peak value of the source voltage is
    a. 14.14 V
    b. 28.28 V
    c. 10 V
    d. 20 V

32. In a parallel RL circuit, there are 2 A_{rms} in the resistive branch and 2 A_{rms} in the inductive branch. The total rms current is
    a. 4 A
    b. 5.656 A
    c. 2 A
    d. 2.828 A

33. If a load is purely inductive and the reactive power is 10 VAR, the apparent power is
    a. 0 VA
    b. 10 VA
    c. 14.14 VA
    d. 3.16 VA

34. For a certain load, the true power is 10 W and the reactive power is 10 VAR. The apparent power is
    a. 5 VA
    b. 20 VA
    c. 14.14 VA
    d. 100 VA

35. The cutoff frequency of a certain low-pass RL filter is 20 kHz. The filter's bandwidth is
    a. 20 kHz
    b. 40 kHz
    c. 0 kHz
    d. unknown

Chapter 14: Resonant Circuits

1. The total impedance of a series RLC circuit at resonance is equal to the resistance.
   a. true
   b. false

2. At resonance, a parallel RLC circuit is capacitive.
   a. true
   b. false

3. At resonance, it is usual for X_C to equal X_L.
   a. true
   b. false

4. The bandwidth of a resonant circuit varies inversely with Q. As Q increases, the bandwidth decreases.
   a. true
   b. false

5. A series resonant circuit has minimum impedance and maximum current.
   a. true
   b. false

6. A parallel resonant circuit has minimum impedance and maximum line current.
   a. true
   b. false

7. At resonance, a parallel RLC circuit is inductive.
   a. true
   b. false

8. At resonance, a series RLC circuit has an impedance equal to the resistance.
   a. true
   b. false

9. At resonance, a series RLC circuit has maximum current.
   a. true
   b. false

10. A resonant RLC circuit is said to be very selective if Q has a low value.
    a. true
    b. false

Chapter 14: Resonant Circuits

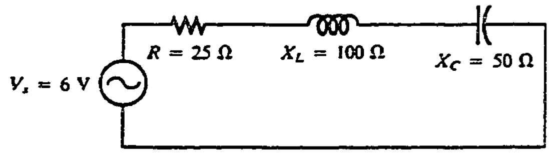


Figure 14-1

11. See figure 14-1. Find the voltage across the capacitor.
    a. 5.37 V
    b. 0.633 V
    c. 10.7 V
    d. -4.9 V

12. See figure 14-1. If you desired to operate this circuit at resonance, you will __________ the resistance and __________ the frequency.
    a. increase, increase
    b. decrease, decrease
    c. not change, increase
    d. not change, decrease

13. See figure 14-1. If the frequency of the source voltage is increased, the impedance will __________ and the current will __________.
    a. decrease, decrease
    b. decrease, increase
    c. increase, increase
    d. increase, decrease

14. See figure 14-1. If the resistance R, were increased, the impedance would
    a. increase
    b. decrease
    c. remain the same
    d. become zero

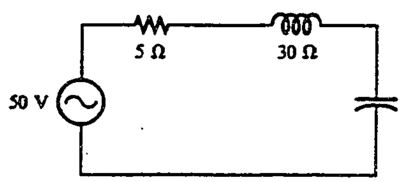


Figure 14-2

Chapter 14: Resonant Circuits

15. See figure 14-2. If the value of R were increased, the bandwidth would
    a. increase.
    b. remain the same.
    c. decrease.
    d. vary.

16. See figure 14-2. If the capacitor opens, the current would
    a. increase because of the inductor.
    b. not change.
    c. decrease.
    d. continue but the circuit would not be resonant.

17. A resonant circuit with a low Q means that it
    a. has a narrow pass-band.
    b. tunes sharply.
    c. has a wide pass-band.
    d. has a small voltage across the capacitor.

18. The resonant frequency of a tank circuit with L = 50 mH and C = 256 pF is
    a. 44.5 Hz
    b. 44.5 kHz
    c. 445 kHz
    d. 4.45 MHz

19. What is the bandwidth of a circuit resonant at 14.2 MHz, if X_c = 3.5 kΩ and the coil resistance is 8 ohm?
    a. 28.4 kHz
    b. 2285 Hz
    c. 14.2 MHz
    d. 32.5 kHz

20. A circuit with X_L = 1.2 kΩ is resonant at 22 kHz. If R = 60 Ω, f_1 = __________ and f_2 = __________.
    a. 21.45 kHz, 22.55 kHz
    b. 21.82 kHz, 22.18 kHz
    c. 20.9 kHz, 23.1 kHz
    d. 21.7 kHz, 22.3 kHz

21. The impedance of a parallel resonant circuit is 0.22 MΩ. Q = 100 and V_s = 50 V. Find the tank current.
    a. 0.227 mA
    b. 0.5 mA
    c. 5 mA
    d. 22.7 mA

Chapter 14: Resonant Circuits

22. A series circuit resonant at 14 MHz has a source voltage of 12 V. The output voltage across the inductor is 300 V. What is the ratio of V_o/V_s expressed in dB?
a. 25 dB
b. 13.98 dB
c. 27.96 dB
d. 42.91 dB

23. A resonant circuit is delivering 120 W. What is the power at f_1 and f_2?
a. 84.84 W
b. 84.84 W at f1 and 60 W at f2
c. 60 W
d. 17 W at both frequencies

24. A tank circuit is operating at a frequency below resonance. The circuit is __________ in nature.
a. resistive
b. capacitive
c. inductive
d. positive

25. You are working on a tuned tank circuit. This circuit tunes with a very narrow bandwidth. Q might be
a. very low.
b. very high.
c. about 10.
d. below 10.

26. See figure 14-1. If the frequency of the source voltage is decreased a little, the impedance will __________ and the phase angle will __________ .
a. increase, increase
b. increase, decrease
c. decrease, decrease
d. decrease, increase

27. See figure 14-2. At resonance the current will be
a. 10 A
b. 10 mA
c. 1.66 A
d. 1.66 mA

28. In a parallel resonant RLC circuit, the impedance is __________ and the total current is __________ .
a. maximum, maximum
b. maximum, minimum
c. minimum, minimum
d. minimum, maximum

Chapter 14: Resonant Circuits

29. The resonant frequency of a tank circuit with L = 0.150 mH and with C = 300 pF is
a. 1.65 MHz.
b. 751 kHz.
c. 347 kHz.
d. 6.05 MHz.

30. A circuit is resonant at 1 MHz. Q = 50. f_1 = ______ and f_2 = __________ .
a. 0.98 MHz, 1.01 MHz
b. 0.99 MHz, 1.01 MHz
c. 0.99 MHz, 1.02 MHz
d. 0.98 MHz, 1.02 MHz

31. The impedance at the resonant frequency of a series RLC circuit with L = 15 mH, C = 0.015 µF, and R = 80 Ω is
a. 15 kΩ
b. 80 Ω
c. 30 Ω
d. 0 Ω

32. In a certain series resonant circuit, V_C = 150 V, V_L = 150 V, and V_R = 50 V. The value of the source voltage is
a. 150 V
b. 300 V
c. 50 V
d. 350 V

33. A certain series resonant band-pass filter has a bandwidth of 1 kHz. If the existing coil is replaced with one having a lower value of Q, the bandwidth will
a. increase
b. decrease
c. remain the same
d. be more selective

34. The total current into the L and C branches at resonance is ideally
a. maximum
b. low
c. high
d. zero

35. The total reactance of a series RLC circuit at resonance is
a. zero
b. equal to the resistance
c. infinity
d. capacitive

Chapter 15: Pulse Response of RC and RL Circuits

1. In an RC integrating circuit, the output is taken across the capacitor.
   a. true
   b. false

2. In an RC integrator, when the pulse width of the input is much less than 5τ, the output approaches the shape of the input.
   a. true
   b. false

3. In an RL integrating circuit, the output is taken across the inductor.
   a. true
   b. false

4. It takes a capacitor 5 time constants to charge completely.
   a. true
   b. false

5. An RC differentiating circuit has the output taken across the resistor.
   a. true
   b. false

6. An RC integrating circuit is a basic high-pass filter with a pulse applied to it.
   a. true
   b. false

7. The output of an RC integrator is the capacitor voltage.
   a. true
   b. false

8. An RL integrator is a basic RL low-pass filter with a pulse applied to it.
   a. true
   b. false

9. In an RC integrator, as the time constant gets longer, the maximum capacitor voltage gets smaller.
   a. true
   b. false

10. The output waveform of an RL integrator is exactly the same as the RC integrator with similar characteristics.
    a. true
    b. false

Chapter 15: Pulse Response of RC and RL Circuits

11. An RC integrating circuit has a 47 kΩ resistor in series with a 0.01 μF capacitor. What is the time constant?
a. 0.047 ms
b. 0.047 μs
c. 0.47 ms
d. 0.47 s

12. An integrating circuit has a 10 kΩ resistor in series with a 470 μF capacitor. What is the time constant?
a. 0.047 μs
b. 0.47 μs
c. 0.47 ms
d. 4.7 s

13. A 1.2 MΩ resistor is in series with a 22 μF capacitor. How long will it take to completely charge the capacitor? The source voltage is 12 V.
a. 132 s
b. 26.4 s
c. 0.264 s
d. 2.64 s

14. A 0.047 μF capacitor is charged to 12 V. You discharge it through a 10 kΩ resistor. How long will it take to completely discharge the capacitor?
a. 5 s
b. 0.47 ms
c. 2.35 ms
d. 0.18 ms

15. A 15 V pulse is applied to an RC integrator. The pulse width equals one time constant. Find V_c at the end of the pulse.
a. 14.7 V
b. 14.25 V
c. 12.975 V
d. 9.48 V

16. An RC integrator uses a 0.47 μF capacitor and a 5 kΩ resistor. A single 15 V pulse is applied for 4.7 ms. Find V_c at the end of the pulse.
a. 9.48 V
b. 12.975 V
c. 14.25 V
d. 14.7 V

17. An RC differentiator circuit uses a 0.01 μF capacitor and a 10 kΩ resistor. The input signal is a square wave with a very short pulse width compared to the time constant. The output signal will be
a. zero volts.
b. a square wave very similar to the input voltage.
c. a dc value of about half the peak input voltage.
d. a dc voltage equal to the peak input voltage.

Chapter 15: Pulse Response of RC and RL Circuits

18. An RL differentiator has the output taken ________ the ________.
    a. across, resistor
    b. across, resistor and inductor
    c. across, inductor
    d. in parallel with, resistor

19. You are trying to completely charge a 100 μF capacitor in 15 seconds. Find the value of the necessary resistor.
    a. 15 kΩ
    b. 30 kΩ
    c. 25 kΩ
    d. 35 kΩ

20. An RL integrator circuit uses an inductor of 2 H and a resistor of 22 kΩ. A pulse with a peak voltage of 12 V is applied for 0.0909 ms. What is the output voltage at the end of the pulse?
    a. 7.58 V
    b. 10.38 V
    c. 11.4 V
    d. 11.76 V

21. An RL integrator circuit has a 200 mH inductor and a 1.2 kΩ resistor. A 5 V dc voltage has been applied to the circuit for 1.2 ms. What is the output voltage at the end of the pulse?
    a. 3.16 V
    b. 4.532 V
    c. 4.75 V
    d. 5 V

22. An RC integrator circuit has a 10 second 50 V pulse applied to it. If R = 10 kΩ and C = 100 μF, what is the output voltage at the end of the pulse?
    a. 31.6 V
    b. 43.25 V
    c. 47.5 V
    d. 50 V

23. How does the RC differentiator output look when 5τ is much less than the pulse width?
    a. positive spikes
    b. positive and negative spikes
    c. negative spikes
    d. square waves

Chapter 15: Pulse Response of RC and RL Circuits

24. A 22 V pulse with a width of 2 ms is applied to an RL integrator with L = 1 H and R = 1 kΩ. What is the output voltage at the end of the pulse?
    a. 13.9 V
    b. 19.03 V
    c. 20.9 V
    d. 21.56 V

25. RC and RL integrators provide __________ output(s) when the inputs are __________.
    a. the same, different
    b. different, different
    c. the same, the same
    d. different, same

26. An integrating circuit has a 4.7 kΩ resistor in series with a 0.005 μF capacitor. What is the time constant?
    a. 0.0235 ms
    b. 2.35 ms
    c. 235 ms
    d. 0.00235 ms

27. A 12 V pulse is applied to an RC integrator. The pulse width equals one time constant. What will the voltage across the capacitor be at the end of the pulse?
    a. 4.41 V
    b. 12 V
    c. 7.58 V
    d. 0 V

28. An RC integrator circuit uses a 0.05 μF capacitor and a 22 kΩ resistor. A single pulse of 12 V is applied to the circuit. The pulse width is 2.2 ms. Determine the capacitor voltage at the end of the pulse.
    a. 10.38 V
    b. 12 V
    c. 7.58 V
    d. 4.42 V

29. An RC integrator uses a 47 μF capacitor and a 12 kΩ resistor. A square wave input with a frequency of 200 kHz is applied. The approximate output of the circuit is
    a. a square wave with a frequency of 100 kHz.
    b. 0 V.
    c. a square wave with a frequency of 200 kHz.
    d. a near dc voltage of about half the peak square wave voltage.

Chapter 15: Pulse Response of RC and RL Circuits

30. An RL integrator circuit uses a 10 mH inductor and a 10 Ω resistor. A pulse with a peak voltage of 16 V is applied for 1 ms. What is the output voltage?
    a. 10.11 V
    b. 13.84 V
    c. 15.2 V
    d. 16.32 V

31. When a 10 V pulse with a width equal to one time constant is applied to an RC integrator, the capacitor charges to
    a. 10 V
    b. 5 V
    c. 6.3 V
    d. 3.7 V

32. When a 10 V pulse with a width equal to one time constant is applied to an RC differentiator, the capacitor charges to
    a. 10 V
    b. 5 V
    c. 6.3 V
    d. 3.7 V

33. In an RC integrator, the output pulse closely resembles the input pulse when
    a. τ is much larger that the pulse width.
    b. τ is equal to the pulse width.
    c. τ is less than the pulse width.
    d. τ is much less than the pulse width.

34. In an RC differentiator, the output pulse closely resembles the input pulse when
    a. τ is much larger that the pulse width.
    b. τ ix equal to the pulse width.
    c. τ is less than the pulse width.
    d. τ is much less than the pulse width.

35. If you have an RC and an RL differentiator with equal time constants sitting side-by-side and you apply the same pulse to both,
    a. the RC has the widest output pulse.
    b. the RL has the most narrow spikes on the output.
    c. the output of one is an increasing exponential and the output of the other is a decreasing exponential.
    d. you can't tell the difference by observing the output waveforms.

APPENDIX E: POSTTEST (QUIZZES)

CHAPTER 3 QUIZ

Student Name____

1. Voltage and resistance are inversely proportional.
   a. true
   b. false

2. A circuit consists of a voltage of 12 V and a resistance of 47 Ω. The circuit's current is 0.255 A.
   a. true
   b. false

3. A circuit consists of a voltage of 12 V and a resistance of 47 Ω. The power dissipated by the resistor is 30.6 W.
   a. true
   b. false

4. If the resistance in a circuit decreases, then the current will increase.
   a. true
   b. false

5. A 47Ω resistor has 0.5 mA flowing through it. It is ok to use a resistor with a power rating of 0.25 W.
   a. true
   b. false

6. Resistance and current are
   a. directly proportional.
   b. inversely proportional.
   c. not related.
   d. are similar to voltage.

7. If the voltage across a circuit decreases, then
   a. the current will increase.
   b. the resistance will decrease.
   c. the resistance will increase.
   d. the current will decrease.

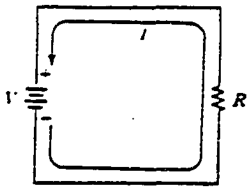


FIGURE 3-2

8. See Figure 3-2. If V = 12 V and R = 12 kΩ, then I =
   a. 0.001 mA
   b. 0.01 mA
   c. 0.1 mA
   d. 1 mA
   e. 10 mA

9. See Figure 3-2. If I = 32 mA and R = 0.469 kΩ, then V =
   a. 12 V
   b. 15 V
   c. 19 V
   d. 22 V

10. See Figure 3-2. If V = 67 V and I = 47 mA, then R =
    a. 1.425 kΩ
    b. 1.67 kΩ
    c. 0.70 kΩ
    d. 3.15 Ω

11. See Figure 3-2. If V = 12 V and R = 12 kΩ and the resistor opens, the current will be
    a. 1 mA
    b. hard to determine.
    c. 0
    d. 10 mA

12. See Figure 3-2. If the voltage is increased in 1-V steps,
    a. the current will decrease in steps.
    b. the resistance will decrease in steps.
    c. the current will increase in steps. .
    d. the resistance and current will not change.

13. See Figure 3-2. If V = 50 V and I = 0.5 mA, then the power dissipated by the resistor is
    a. 25 W
    b. 2.5 W
    c. 0.25 W
    d. 25 mW

14. See Figure 3-2. If V = 50 V and I = 5 A, then the resistor must be capable of dissipating
    a. 250 W
    b. 10 W
    c. 1 W
    d. 250 mW

15. A circuit consisting of a resistor color coded red, red, red is placed across a source of 12 V. What value resistor and wattage rating could be used?
    a. 22,000 Ω at 1/4 W
    b. 2200 Ω at 1/2 W
    c. 22 kΩ at 1/4 W
    d. 220 Ω at 1/8 W

16. Which of the following terms is <u>not</u> a resistor rating?
    a. resistor value in ohms
    b. resistor tolerance
    c. current
    d. power rating

17. See Figure 3-2. V = 12 V and R has the color codes brown, black, orange. You measure the current in the circuit. What limits of current might you expect to measure?
    a. 1.2 mA and 1.4 mA
    b. 1 mA and 1.6 mA
    c. 0.8 mA and 1.2 mA
    d. 1 mA and 1.5 mA

18. See Figure 3-2. The resistor is very hot to touch. What should you do to remedy the problem? The current is correct.
    a. Increase the voltage.
    b. Put in a resistor with a smaller value.
    c. Replace the resistor with one of a larger power rating.
    d. Wait for it to burn out and then fix it.

19. A 40-W lightbulb has a resistance measurement of 24 Ω when out of the circuit. What is the resistance of the bulb when it is hot and in a circuit with a supply of 120 V?
    a. 180 Ω
    b. 0.003 Ω
    c. 360 Ω
    d. 1200 Ω

20. See Figure 3-2. If the resistor develops an open,
    a. the power dissipated will increase
    b. the circuit current will decrease.
    c. the source voltage will decrease to zero.
    d. the resistance will decrease.

CHAPTER 4 QUIZ

Student Name ______________________________

1. In a series circuit, the sum of the individual resistor currents equals the total current.
   a. true
   b. false

2. The sum of the individual voltage drops in a series circuit equals the source voltage. This is Kirchhoff's voltage law.
   a. true
   b. false

3. The total power used in a series circuit is the product of each individual resistor's power.
   a. true
   b. false

4. Three resistors, 4.7 kΩ, 1.2 kΩ, and 3.3 kΩ are in series. The total resistance is 9200 Ω.
   a. true
   b. false

5. A 1/2-W resistor can safely dissipate more than 1/2 W.
   a. true
   b. false

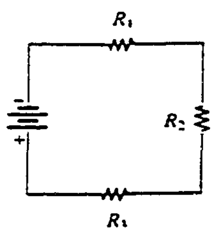


FIGURE 4-1

6. See Figure 4-1. R_1 = 12 kΩ, R_2 = 4.7 kΩ, and R_3 = 2.2 kΩ.
   R_T =
   a. 19.8 kΩ
   b. 18.9 kΩ
   c. 8.6 kΩ
   d. 1.33 kΩ

7. See Figure 4-1. If R_3 opens and the source voltage is 12 V, the current is
   a. 12 V
   b. maximum.
   c. 0
   d. unable to be determined.

8. See Figure 4-1. R_1 = 12 kΩ, R_2 = 4.7 kΩ, R_3 = 2.2 kΩ, and V_S = 50 V. The current is
   a. 26.5 mA
   b. 378 mA
   c. 0
   d. 2.65 mA

9. Refer to problem 8. V_{R1} is
   a. 31.8 V
   b. 63.6 V
   c. 5.8 V
   d. 12.4 V

10. Refer to problem 8. V_{R2} is
   a. 16.4 V
   b. 31.8 V
   c. 12.4 V
   d. 5.8 V

11. Refer to problem 8. If R_2 shorts, the voltage drop across R_1 will
   a. increase
   b. decrease
   c. remain the same

12. Refer to problem 8. If R_3 opens, the voltage drop across R_2 will be
   a. 16.5 V
   b. 33.5 V
   c. 9 V
   d. 0 V

13. Refer to problem 8. The total power dissipated in the circuit is
   a. 132.5 mW
   b. 132.5 W
   c. 84 mW
   d. 33 mW

14. Refer to problem 8. If R_1 is shorted out, the total power dissipated by the circuit will
   a. increase
   b. decrease
   c. remain the same

15. Two power supplies are in series with voltages of 12 V and 17 V respectively. What is the total supply voltage?
   a. 5 V
   b. -5 V
   c. 29 V
   d. -29 V

16. Two resistors are in series across a source of 20 V. Each resistor has a value of 100 kΩ. What is the voltage across each resistor?
   a. 20 V
   b. 10 V
   c. 100 mA
   d. 100 kΩ

17. A two-resistor voltage divider has R_1 = 22 kΩ and R_2 = 12 kΩ across 47 V. What is the voltage across R_2?
    a. about 16.6 V
    b. about 30.4 V
    c. about 25.6 V
    d. about 17.2 V

18. A 500 kΩ pot is connected across 5 V. The voltage from the wiper to the lower end of the pot is 1.2 V. What is the resistance of the lower part of the pot?
    a. 380 kΩ
    b. 120 kΩ
    c. 500 kΩ
    d. 0 Ω

19. Three batteries are in series with potentials of 1.2 V, 5 V, and 6 V, but the 1.2-V battery is opposing the other two. The total supply voltage is
    a. 12.2 V
    b. 9.8 V
    c. 1.2 V
    d. 1.3 V

20. Three sources are connected in series aiding. Each has a potential of 8 V. What is the total circuit voltage?
    a. 32 V
    b. 24 V
    c. 16 V
    d. 8 V

CHAPTER 5 QUIZ

Student Name ______________________________

1. Four resistors are connected in parallel. The voltage across one resistor is 14 V. The voltage across the other resistors will also be 14 V.
   a. true
   b. false

2. The sum of the values of four resistors in parallel equals the total resistance.
   a. true
   b. false

3. A parallel branch has 1.2 mA flowing. The other branch has 3.4 mA. The total current into the junction of these branches is 4.6 mA.
   a. true
   b. false

4. If an open occurs in one branch of a parallel circuit, then the total current will increase.
   a. true
   b. false

5. The total power dissipated in a parallel circuit is the sum of the individual powers.
   a. true
   b. false

6. A circuit of three parallel resistors, 1.2 kΩ, 4.7 kΩ, and 6.8 kΩ is supplied with a 20-V source. What is the total resistance?
   a. 838 Ω
   b. 1200 Ω
   c. 4700 Ω
   d. 6800 Ω
   e. 12,700 Ω

7. Refer to the values of problem 6. The current through the 4.7-kΩ resistor is
   a. 16.7 mA
   b. 4.25 mA
   c. 2.94 mA
   d. 1.57 mA

8. Two resistors are in parallel, 1500 Ω and 5000 Ω. The total resistance of the circuit is
   a. 1500 Ω
   b. 5000 Ω
   c. greater than 5000 Ω
   d. less than 1500 Ω

9. A parallel circuit consisting of R_1 = 100 Ω, R_2 = 500 Ω, and R_3 has an R_T = 76.92 Ω. Find the value of R_3.
   a. 140 Ω
   b. 1000 Ω
   c. 1850 Ω
   d. There is not enough data to compute.

10. A parallel circuit consists of R_1 = 1.2 kΩ in parallel with R_2. I_T = 5 μA and I_2 = 3 μA. What is the value of V_{R1}?
   a. 6 mV
   b. 18 mV
   c. 3.6 mV
   d. 2.4 mV

11. Three resistors are connected in parallel across 50 V. The values are 680 kΩ, 0.047 MΩ and 470 kΩ. If the 0.047-MΩ resistor opens, the total current, I_T, will be
   a. 1.2 mA
   b. 555 μA
   c. 180 μA
   d. 790 μA

12. Six 1.2-MΩ resistors are connected in parallel across 12 V. What is the total resistance of the circuit?
   a. 1.2 MΩ
   b. 250 kΩ
   c. 200 kΩ
   d. 120 kΩ

13. Three parallel branches have a total current of 45 μA flowing into them. I_1 = 15 μA and I_2 = 19 μA. Find the current in the third branch.
   a. 34 μA
   b. 26 μA
   c. 30 μA
   d. 11 μA

14. As resistors are added in parallel to a circuit,
   a. I_T decreases and R_T increases.
   b. I_T decreases and R_T decreases.
   c. I_T increases and R_T decreases.
   d. I_T increases and R_T increases.

15. If a resistor in parallel opens, the total current will
   a. increase and the voltage will decrease.
   b. decrease and the voltage will be constant.
   c. increase and the fuse will blow.
   d. decrease and the voltage will increase.

16. The total power in a parallel circuit
   a. is the sum of the individual powers.
   b. is found by V_T/I_T.
   c. is the sum of the individual powers minus the total power.
   d. is found by $I_1^2R_1$.

17. A circuit consists of three resistors in parallel, R_1 = 4.7 kΩ, R_2 = 3.3 kΩ, and R_3. I_T = 35 mA and V_S = 50 V. Find I_{R3}.
   a. 10.64 mA
   b. 15.15 mA
   c. 9.21 mA
   d. 4.72 mA

18. 680 mA flow into four parallel resistors. The currents through three of the resistors are 95 mA, 400 mA, 19 mA. The current through the fourth resistor is
   a. 585 mA
   b. 280 mA
   c. 261 mA
   d. 166 mA

19. Two resistors are in parallel. R_1 = 470 Ω and R_T = 330 Ω. Find the value of R_2.
   a. 770 Ω
   b. 1108 Ω
   c. 194 Ω
   d. 110 Ω

20. House wiring of lamps are usually in parallel
   a. so they will draw less current.
   b. because the resistance is higher.
   c. so one lamp burnout will not affect the other lamps.
   d. because the power is greater than in a series circuit.

CHAPTER 5 QUIZ

Student Name ______________________________

1. Four resistors are connected in parallel. The voltage across one resistor is 14 V. The voltage across the other resistors will also be 14 V.
   a. true
   b. false

2. The sum of the values of four resistors in parallel equals the total resistance.
   a. true
   b. false

3. A parallel branch has 1.2 mA flowing. The other branch has 3.4 mA. The total current into the junction of these branches is 4.6 mA.
   a. true
   b. false

4. If an open occurs in one branch of a parallel circuit, then the total current will increase.
   a. true
   b. false

5. The total power dissipated in a parallel circuit is the sum of the individual powers.
   a. true
   b. false

6. A circuit of three parallel resistors, 1.2 kΩ, 4.7 kΩ, and 6.8 kΩ is supplied with a 20-V source. What is the total resistance?
   a. 838 Ω
   b. 1200 Ω
   c. 4700 Ω
   d. 6800 Ω
   e. 12,700 Ω

7. Refer to the values of problem 6. The current through the 4.7-kΩ resistor is
   a. 16.7 mA
   b. 4.25 mA
   c. 2.94 mA
   d. 1.57 mA

8. Two resistors are in parallel, 1500 Ω and 5000 Ω. The total resistance of the circuit is
   a. 1500 Ω
   b. 5000 Ω
   c. greater than 5000 Ω
   d. less than 1500 Ω

9. A parallel circuit consisting of R_1 = 100 Ω, R_2 = 500 Ω, and R_3 has an R_T = 76.92 Ω. Find the value of R_3.
   a. 140 Ω
   b. 1000 Ω
   c. 1850 Ω
   d. There is not enough data to compute.

10. A parallel circuit consists of R_1 = 1.2 kΩ in parallel with R_2. I_T = 5 μA and I_2 = 3 μA. What is the value of V_{R1}?
    a. 6 mV
    b. 18 mV
    c. 3.6 mV
    d. 2.4 mV

11. Three resistors are connected in parallel across 50 V. The values are 680 kΩ, 0.047 MΩ and 470 kΩ. If the 0.047-MΩ resistor opens, the total current, I_T, will be
    a. 1.2 mA
    b. 555 μA
    c. 180 μA
    d. 790 μA

12. Six 1.2-MΩ resistors are connected in parallel across 12 V. What is the total resistance of the circuit?
    a. 1.2 MΩ
    b. 250 kΩ
    c. 200 kΩ
    d. 120 kΩ

13. Three parallel branches have a total current of 45 μA flowing into them. I_1 = 15 μA and I_2 = 19 μA. Find the current in the third branch.
    a. 34 μA
    b. 26 μA
    c. 30 μA
    d. 11 μA

14. As resistors are added in parallel to a circuit,
    a. I_T decreases and R_T increases.
    b. I_T decreases and R_T decreases.
    c. I_T increases and R_T decreases.
    d. I_T increases and R_T increases.

15. If a resistor in parallel opens, the total current will
    a. increase and the voltage will decrease.
    b. decrease and the voltage will be constant.
    c. increase and the fuse will blow.
    d. decrease and the voltage will increase.

16. The total power in a parallel circuit
    a. is the sum of the individual powers.
    b. is found by V_T/I_T.
    c. is the sum of the individual powers minus the total power.
    d. is found by $I_1^2R_1$.

17. A circuit consists of three resistors in parallel, $R_1 = 4.7\ k\Omega$, $R_2 = 3.3\ k\Omega$, and R_3. $I_T = 35$ mA and $V_S = 50$ V. Find I_{R3}.
    a. 10.64 mA
    b. 15.15 mA
    c. 9.21 mA
    d. 4.72 mA

18. 680 mA flow into four parallel resistors. The currents through three of the resistors are 95 mA, 400 mA, 19 mA. The current through the fourth resistor is
    a. 585 mA
    b. 280 mA
    c. 261 mA
    d. 166 mA

19. Two resistors are in parallel. $R_1 = 470\ \Omega$ and $R_T = 330\ \Omega$. Find the value of R_2.
    a. 770 Ω
    b. 1108 Ω
    c. 194 Ω
    d. 110 Ω

20. House wiring of lamps are usually in parallel
    a. so they will draw less current.
    b. because the resistance is higher.
    c. so one lamp burnout will not affect the other lamps.
    d. because the power is greater than in a series circuit.

CHAPTER 6 QUIZ

Student Name ____

1. To avoid loading effects, a voltmeter should have a low internal resistance.
   a. true
   b. false

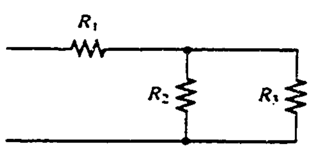


FIGURE 6-1

2. See Figure 6-1. R_1 is in series with R_2.
   a. true
   b. false

3. See Figure 6-1. R_1 is in series with the parallel combination R_2 and R_3.
   a. true
   b. false

4. Resistors are in parallel if they share the same current.
   a. true
   b. false

5. In a combination circuit, the total resistance can be represented by one resistor of the correct value.
   a. true
   b. false

6. See Figure 6-1. Resistor R_1 is connected
   a. in series with R_2.
   b. in series with R_3.
   c. in parallel with R_2.
   d. in parallel with R_3.
   e. None of these.

7. See Figure 6-2. R_1 and R_4 are connected
   a. in series with each other and R_3.
   b. in series with each other, R_2, and R_3.
   c. in series with each other.
   d. in parallel with R_3.

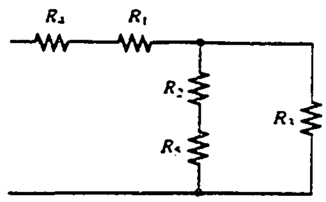


FIGURE 6-2

8. See Figure 6-2. R_2 and R_3 are connected
   - a. in series with each other and in parallel with R_3.
   - b. in parallel.
   - c. in series with R_1.
   - d. in series with R_3.

9. See Figure 6-1. If R_1 = 4.7 kΩ, R_2 = 3300 Ω, and R_3 = 1000 Ω, the total resistance of the circuit is
   - a. 5700 Ω
   - b. 5467 Ω
   - c. 4125 Ω
   - d. 660 Ω

10. See Figure 6-1 and the values in problem 9. If the source voltage is 50 V, calculate the total current.
    - a. 8.8 mA
    - b. 9.15 mA
    - c. 12.1 mA
    - d. 75.7 mA

11. Refer to problem 10. The voltage drop across R_3 is
    - a. 42.9 V
    - b. 5.62 V
    - c. 7.01 V
    - d. 1.76 V

12. See Figure 6-2. If all of the resistors are 33 kΩ, the total resistance is
    - a. 165 kΩ
    - b. 55 kΩ
    - c. 116.5 kΩ
    - d. 88 kΩ

13. See Figure 6-2. If all of the resistors are 1000 Ω and the source voltage is 25 V, the voltage drop across R_3 is
    - a. 6.25 V
    - b. 43.75 V
    - c. 18.75 V
    - d. 25 V

14. See Figure 6-1. If another resistor is placed in parallel with R_3,
   a. V_{R1} will decrease.
   b. V_{R2} will decrease.
   c. I_1 will decrease.
   d. I_2 will increase.

15. See Figure 6-3. If V_{R2} = 12 V, find V_{DE}.
   a. -12 V
   b. 12 V
   c. 24 V
   d. 36 V

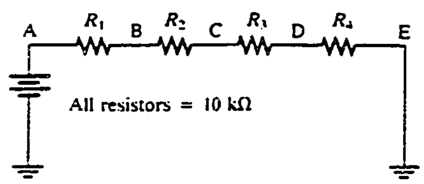


FIGURE 6-3

16. See Figure 6-3. If V_D = 9.6 V, find V_{DB}.
   a. 9.6 V
   b. 4.8 V
   c. 19.2 V
   d. -19.2 V

17. See Figure 6-2. If R_2 shorts, I_5 will
   a. increase.
   b. decrease.
   c. remain the same.

18. See Figure 6-2. If R_3 opens, V_{R4} will
   a. increase.
   b. decrease.
   c. remain the same.

19. See Figure 6-2. If R_4 shorts, V_{R3} will
   a. increase.
   b. decrease.
   c. remain the same.

20. If a combination of four parallel 10-kΩ resistors were in series with a single 20-kΩ resistor, and one of the parallel combination resistors opened, the voltage across the other parallel resistors would
   a. increase.
   b. decrease.
   c. remain the same.

CHAPTER 8 QUIZ

Student Name ______________________________

1. The period of a sine wave is the reciprocal of the frequency.
   a. true
   b. false

2. The higher the frequency of a sine wave, the longer the period.
   a. true
   b. false

3. The peak value of a sine wave is larger in value than the rms value.
   a. true
   b. false

4. If an ac voltage is applied to a resistor, the current decreases as the voltage increases.
   a. true
   b. false

5. Sine, square, and triangle waves are all forms of ac waves.
   a. true
   b. false

6. The formula for V_{rms} for a sine wave is
   a. $V_{p\text{-}p} \times 0.707$
   b. $V_p \times 0.707$
   c. $V_p \times 1.414$
   d. $V_{p\text{-}p} \times 1.414$

7. The rms value of a sine wave voltage means
   a. the heating effect of a battery of the same voltage.
   b. the root mean square value.
   c. $I_{rms} \times R$.
   d. all of these.

8. A sine wave has a peak value of 169 V. What is the instantaneous value at an angle of 37°?
   a. 135 V
   b. 119 V
   c. 239 V
   d. 102 V

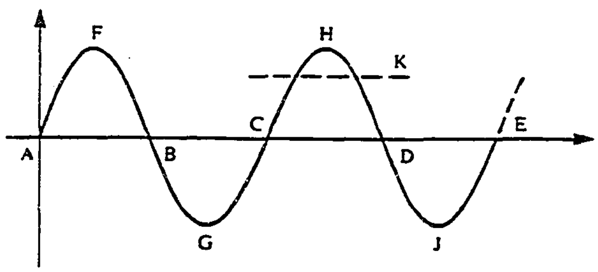


FIGURE 8-1

9. See Figure 8-1. The figure shows
   a. four complete cycles.
   b. four positive and four negative alternations.
   c. two complete cycles.
   •d. four positive alternations.
   e. four negative alternations.

10. The number of cycles occurring in one second is called
    a. an alternation.
    b. revolutions per minute.
    c. alternating current.
    d. the frequency.

11. See Figure 8-1. The time from point B to point C is called
    a. an alternation.
    b. a cycle.
    c. the period.
    d. peak voltage.

12. See Figure 8-1. The voltage value at point H represents
    a. rms voltage.
    b. p-p voltage.
    c. peak voltage.
    d. one cycle of voltage.

13. See Figure 8-1. The rms voltage is seen at point
    a. J
    b. K
    c. F
    d. E

14. See Figure 8-1. The time from points G to J is known as
    a. one cycle.
    b. one alternation.
    c. the rms value.
    d. V_p.

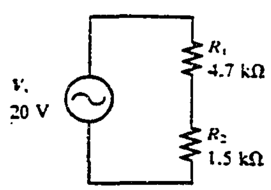


FIGURE 8-2

15. See Figure 8-2. Find V_{R1}.
    a. 15.16 $V_{p\text{-}p}$
    b. 42.88 V_p
    c. 21.43 V_p
    d. 15.16 V_p

16. See Figure 8-2. Find $I_{p\text{-}p}$.
    a. 4.55 mA
    b. 3.22 mA
    c. 9.12 mA
    d. 6.44 mA

17. See Figure 8-2. Find $V_{R2(p\text{-}p)}$.
    a. 4.84 V
    b. 9.68 V
    c. 13.68 V
    d. 6.84 V

18. The correct formula for finding the period (T) of a sine wave is
    a. T = 1/f
    b. f = 1/T
    c. T = 0.707f
    d. T = 1.414f

19. Your scope is set up to measure a voltage, but the trace is a straight horizontal line. The problem could be
    a. there is no voltage to the circuit.
    b. the scope is connected to ground.
    c. the input scope switch is set to the ground position.
    d. any of these.

20. A square wave consists of
    a. a fundamental and even harmonics.
    b. a fundamental and all harmonics.
    c. a fundamental and odd harmonics.
    d. even and odd harmonics only.

CHAPTER 9 QUIZ

Student Name ______________________________________

1. The measure of a capacitor's ability to store charge is called capacitance.
   a. true
   b. false

2. A capacitor blocks ac and passes dc.
   a. true
   b. false

3. If two capacitors are in series across a dc source, the largest capacitor has the largest voltage across it.
   a. true
   b. false

4. If the area of the plates of a capacitor is increased, the capacitance increases.
   a. true
   b. false

5. The time required for a capacitor to charge by 63.2% is called the time constant.
   a. true
   b. false

6. A capacitor has a charge of 2500 μC and a voltage across it of 25 V. The capacitance is
   a. 0.01 μF
   b. 0.1 μF
   c. 10 μF
   d. 100 μF

7. A 4.7-μF capacitor has a voltage across it of 50 V. What charge is stored in the capacitor?
   a. 235 μC
   b. 470 μC
   c. 23.5 μC
   d. 2.35 μC

8. The dc working voltage of a capacitor is 100 V. This means that the dielectric must be able to withstand
   a. 100 V dc
   b. 100 V_{peak}
   c. 200 $V_{p\text{-}p}$
   d. all of the above

9. Two equal value capacitors of 200 μF each are in parallel across 50 V. What is C_T and the voltage across each capacitor?
   a. 100 μF and 25 V
   b. 400 μF and 50 V
   c. 400 μF and 25 V
   d. 200 μF and 50 V

10. Three capacitors are in series. C_1 = 100 μF, C_2 = 100 μF, and C_3 = 50 μF. The source voltage is 75 V. What is the voltage across C_3?
   a. 18.75 V
   b. 50 V
   c. 37.5 V
   d. 100 V

11. A 0.001-μF capacitor is in series with a 10-kΩ resistor. What is the circuit's time constant?
   a. 10 μs
   b. 100 μs
   c. 0.1 s
   d. 1 s

12. A 0.047-μF capacitor is in series with a 1-MΩ resistor. How long will it take to completely charge the capacitor? The supply voltage is 50 V.
   a. 0.047 s
   b. 0.029 s
   c. 0.235 s
   d. 0.47 s

13. A 100 μF-capacitor is charged to 25 V. You attempt to discharge the capacitor through a 22-kΩ resistor. How long will it take to completely discharge?
   a. 2.2 s
   b. 4.4 s
   c. 11 s
   d. 132 s

14. A 0.01-μF capacitor is in series with a 2.2-kΩ resistor. A voltage of 30 V is applied when a switch is closed. What will the voltage across the capacitor be after one time constant?
   a. 29.4 V
   b. 28.50 V
   c. 25.95 V
   d. 18.96 V

15. A 2.2-μF capacitor with a 1-kHz ac voltage applied to it will have _______ X_C.
   a. infinite
   b. zero
   c. 72.4 Ω
   d. 0.013 Ω

16. A 159-pF capacitor has an X_C of 502 Ω. What is the operating frequency?
   a. 2 kHz
   b. 20 kHz
   c. 200 kHz
   d. 2000 kHz

17. An ohmmeter is used to test the resistance of a capacitor. The reading in both directions is 0 Ω. The capacitor is probably
   a. open.
   b. shorted.
   c. leaking.
   d. completely charged.

18. If the frequency applied to a capacitor is increased, the capacitive reactance will
   a. increase.
   b. decrease.
   c. remain the same.
   d. vary up and down.

19. A 47-μF capacitor is connected to a 5-V 400-Hz source. The current will be
   a. 590 mA
   b. 1.69 mA
   c. 94 mA
   d. 188 mA

20. A capacitor that will transfer an ac signal from one stage to another is called
   a. a bypass capacitor.
   b. a filter capacitor.
   c. a coupling capacitor.
   d. a transfer capacitor.

CHAPTER 10 QUIZ

Student Name ______________________________

1. The total inductance of series inductors is the sum of all the inductances.
   a. true
   b. false

2. The energy stored in an inductor's electrostatic field is produced by the current.
   a. true
   b. false

3. An inductor passes ac and opposes dc.
   a. true
   b. false

4. Inductive reactance increases when the frequency is increased.
   a. true
   b. false

5. In an inductive circuit, the current leads the voltage.
   a. true
   b. false

6. Two 2.5-mH inductors are in series with a 4.7-kΩ resistor. The source voltage is 100 V. What is the maximum current in this circuit?
   a. 21.3 mA
   b. 63.2 mA
   c. 1.1 mA
   d. 7.9 mA

7. An inductor has a dc current flowing through it. The magnetic field
   a. is changing constantly.
   b. is collapsing.
   c. is said to move from south to north.
   d. is said to move from north to south.

8. If a coil of wire is wound on an iron rod, the magnetic field
   a. is weaker than if a paper tube were used as the core.
   b. is weaker than if the core were air.
   c. is stronger than a coil wound on a paper tube.
   d. will collapse.

9. A frequency of 10 kHz is applied to a coil with an inductance of 150 mH. What is the inductive reactance?
   a. 1500 Ω
   b. 6280 Ω
   c. 8450 Ω
   d. 9420 Ω

10. In an inductive circuit, the _______ leads the ________.
    a. voltage, power
    b. current, voltage
    c. voltage, current
    d. power, current

11. As frequency is increased, X_L
    a. increases
    d. decreases
    c. remains the same
    d. changes up and down

12. A 50-mH inductor has an X_L of 5000 Ω. What is the applied frequency?
    a. 159 Hz
    b. 1590 Hz
    c. 15,923 Hz
    d. 159,235 Hz

13. A 50-mH inductor is in series with a 5-kΩ resistor. What is the time constant?
    a. 10 μs
    b. 100 s
    c. 250 s
    d. 10 ms

14. How many time constants does it take to completely build up a magnetic field around an inductor?
    a. one
    b. two
    c. four
    d. five

15. A series inductor with an inductance of 10 mH and a winding resistance of 50 Ω is applied to a 500-Hz source. What is the inductive reactance?
    a. 0.032 Ω
    b. 31.4 Ω
    c. 0.5 Ω
    d. 31.4 kΩ

16. A 40-mH inductor is in parallel with a 24-mH inductor. The total inductance is
    a. 64 mH
    b. 32 mH
    c. 15 mH
    d. 15.39 mH

17. You think that an inductor is faulty. You measure the resistance at 0 Ω. The dc voltage across the coil measures zero. The probable fault, if any, is
    a. the coil is shorted.
    b. the coil is open.
    c. the coil is normal.
    d. the coil will work on ac.

18. An inductor is placed in an ac circuit with a voltage of 20 V. The current is 250 mA. What is the inductive reactance?
    a. 0.0125 Ω
    b. 160 Ω
    c. 80 Ω
    d. Cannot be computed since no frequency is given

19. If 50 V at a frequency of 5 kHz were measured across an inductor with an inductance of 500 mH, what would be the current?
    a. 6.36 mA
    b. 3.18 mA
    c. 1.59 mA
    d. 0.08 mA

20. A coil of wire is carrying a dc current of 50 mA. The X_L of the coil at 60 Hz is 400 Ω. The voltage across the coil is 25 V. What is the resistance of the coil?
    a. 500 Ω
    b. 400 Ω
    c. 16 Ω
    d. 20 Ω

CHAPTER 11 QUIZ

Student Name ____

1. The number of turns in the primary and secondary determines the turns ratio.
   a. true
   b. false

2. Maximum power is moved from the secondary to the primary when the source resistance is equal to the load resistance.
   a. true
   b. false

3. A transformer with a turns ratio of 0.5 is a step-up transformer.
   a. true
   b. false

4. The core materials of transformers are often laminated iron or air.
   a. true
   b. false

5. Transformers are efficient devices.
   a. true
   b. false

6. A step-down transformer will decrease________ and increase ________.
   a. resistance, power
   b. current, voltage
   c. voltage, current
   d. power, current

7. The loss in a transformer due to the changing magnetic field is called
   a. eddy current loss.
   b. hysteresis loss.
   c. I^2R loss.
   d. flux leakage loss.

8. A step-up transformer will increase________ and decrease________.
   a. voltage, impedance
   b. voltage, power
   c. current, impedance
   d. power, current

9. The loss in a transformer due to currents flowing in the core is called
   a. hysteresis loss.
   b. winding loss.
   c. flux leakage loss.
   d. eddy current loss.

10. To transfer the most power from the source to the load,
   a. the source resistance must be larger than the load resistance.
   b. the load resistance must equal the power loss.
   c. the source resistance must equal the load resistance.
   d. the power in the primary and secondary must be equal.

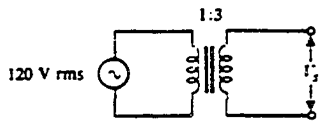


FIGURE 11-1

11. See Figure 11-1. There are five times as many turns in the secondary as the primary. What is the secondary voltage, V_s?
   a. 24 V
   b. 240 V
   c. 560 V
   d. 600 V

12. See Figure 11-1. If the ratio of primary-to-secondary turns is 4.5:1, what is the output voltage, V_s?
   a. 540 V
   b. 26.67 V
   c. 5.92 V
   d. 4.72 V

13. See Figure 11-1. If the primary-to-secondary turns ratio is 4:1, and a load resistor of 50 Ω is in the secondary, what is the secondary current?
   a. 1.66 A
   b. 600 mA
   c. 9.6 A
   d. 4.8 A

14. See Figure 11-1. The primary-to-secondary turns ratio is 4:1 and I_s = 40 mA. What is the primary current?
   a. 160 mA
   b. 40 mA
   c. 10 mA
   d. 4 mA

15. See Figure 11-1. The primary-to-secondary turns ratio is 4:1 and I_s = 40 mA. What is the reflected resistance seen by the primary?
    a. 4 kΩ
    b. 8 kΩ
    c. 12 kΩ
    d. 16 kΩ

16. What ratio would transform 100 V into 40 V?
    a. 40:100
    b. 4:1
    c. 400:1000
    d. 2.5:1

17. The primary-to-secondary turns ratio is 60:5 and the primary voltage and current is 120 V and 75 mA. What is the primary power?
    a. 0.75 W
    b. 1.25 W
    c. 9 W
    d. 9.6 W

18. A transformer measures full voltage across the primary terminals but there is no voltage delivered to the load. The trouble might be
    a. a short across the secondary.
    b. an open primary.
    c. a shorted primary.
    d. an open transformer core.

19. You desire to match a 300-ohm load to a 75-ohm source. What would be the primary-to-secondary turns ratio of the transformer?
    a. 1:2
    b. 2:1
    c. 1:4
    d. 4:1

20. You have a need to isolate two circuits with no change of voltage. You would use a/an____________transformer with a turns ratio of _______.
    a. step-up, 2:1
    b. step-down, 1:1
    c. step-up, 1:1
    d. isolation, 1:1

CHAPTER 12 QUIZ

Student Name ____

1. When a sine wave is applied to an RC circuit, the current and all the voltage drops are also sine waves.
   a. true
   b. false

2. The current in an RC series circuit always lags the source voltage.
   a. true
   b. false

3. The phasor combination of true power and reactive power is called apparent power.
   a. true
   b. false

4. A filter blocks certain frequencies and passes others.
   a. true
   b. false

5. The phase angle of a series RC circuit varies directly with frequency.
   a. true
   b. false

6. See Figure 12-1. Calculate for the total impedance.
   a. 418 Ω
   b. 520 Ω
   c. 280 Ω
   d. 120 Ω

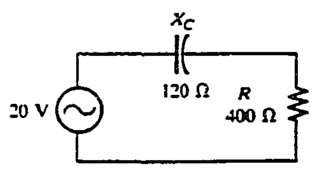


FIGURE 12-1

7. See Figure 12-1. Calculate the phase angle.
   a. 73.3°
   b. 17.5°
   c. 16.7°
   d. 72.5°

8. See Figure 12-1. Calculate the voltage drop across the capacitor.
   a. 19.14 V
   b. 16.7 V
   c. 20 V
   d. 5.75 V

9. See Figure 12-1. Calculate the true power.
   a. 275 mW
   b. 916 mW
   c. 956 mW
   d. 1002 mW

10. See Figure 12-1. Calculate the apparent power.
    a. 0.874 VA
    b. 0.916 VA
    c. 0.957 VA
    d. 0.989 VA

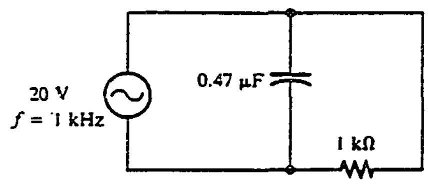


FIGURE 12-2

11. See Figure 12-2. Find the current through the capacitor.
    a. 20 mA
    b. 62 mA
    c. 321 mA
    d. 59 mA

12. See Figure 12-2. Find the total impedance.
    a. 1000 Ω
    b. 880 Ω
    c. 321 Ω
    d. 62 Ω

13. See Figure 12-2. Find the phase angle.
    a. 18.7°
    b. 71.3°
    c. 14.7°
    d. 3.2°

14. See Figure 12-2. Find the apparent power.
   a. 1.18 VA
   b. 0.4 VA
   c. 1.246 VA
   d. 0.95 VA

15. See Figure 12-2. What is the power factor?
   a. 0.947
   b. 0.321
   c. 0.338
   d. 2.95

16. See Figure 12-1. If the frequency is increased, the phase angle will_________and the impedance will_________.
   a. decrease, increase
   b. increase, decrease
   c. decrease, decrease
   d. increase, increase

17. See Figure 12-2. If the frequency is decreased, the total current will_________and the total impedance will_________.
   a. decrease, increase
   b. increase, decrease
   c. decrease, decrease
   d. increase, increase

18. See Figure 12-1. If the output were across the resistor, the circuit would be known as a
   a. low-pass filter.
   b. high-pass filter.
   c. band-pass filter.
   d. band-reject filter.

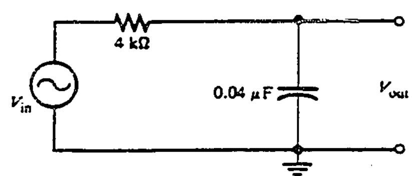


FIGURE 12-3

19. See Figure 12-3. The cutoff frequency is
   a. 6250 Hz
   b. 99 Hz
   c. 480 Hz
   d. 995 Hz

20. See Figure 12-3. If the input voltage were 17 V, what would the voltage be across the capacitor at the cutoff frequency?

a. 0 V
b. 8 V
c. 12 V
d. 17 V

CHAPTER 13 QUIZ

Student Name ____

1. Total current in an RL circuit always leads the source voltage.
   a. true
   b. false

2. A low-pass filter passes low frequencies and blocks other frequencies.
   a. true
   b. false

3. The impedance of an RL circuit varies directly with frequency.
   a. true
   b. false

4. In a filter circuit using RL components, an increase in the value of R will increase the cutoff frequency.
   a. true
   b. false

5. The impedance of a parallel RL circuit is found by adding X_L to R.
   a. true
   b. false

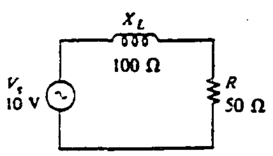


FIGURE 13-1

6. See Figure 13-1. Find the impedance.
   a. 104 Ω
   b. 112 Ω
   c. 1120 Ω
   d. 1040 Ω

7. See Figure 13-1. Find the phase angle.
   a. 26.6°
   b. 0.034°
   c. 63.4°
   d. 45°

8. See Figure 13-1. Find the voltage across the inductor.
   a. 0.4 V
   b. 0.894 V
   c. 4.47 V.
   d. 8.94 V.

9. See Figure 13-1. Find the true power.
   a. 400 mW
   b. 0.894 W
   c. 0.8 W
   d. 112 mW

10. See Figure 13-1. Find the apparent power.
   a. 0.4 VA
   b. 0.8 VA
   c. 8.94 VA
   d. 0.894 VA

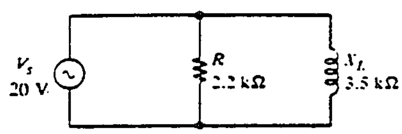


FIGURE 13-2

11. See Figure 13-2. Find the current through the inductor.
   a. 5.71 mA
   b. 0.182 mA
   c. 9.09 mA
   d. 2.15 mA

12. See Figure 13-2. Find the total impedance.
   a. 10.74 kΩ
   b. 9.09 kΩ
   c. 5.71 kΩ
   d. 1.86 kΩ

13. See Figure 13-2. Find the phase angle.
   a. 32.15°
   b. 57.85°
   c. 45°
   d. 53.2°

14. See Figure 13-2. Find the apparent power.
   a. 0.182 VA
   b. 0.532 VA
   c. 1.86 VA
   d. 0.215 VA

15. See Figure 13-2. Find the power factor.
   a. 0.707
   b. 0.846
   c. 0.532
   d. 0.599

16. See Figure 13-1. If the frequency is increased, the phase angle will________ and the impedance will________.
   a. decrease, increase
   b. increase, decrease
   c. decrease, decrease
   d. increase, increase

17. See Figure 13-2. If the frequency is decreased, the total current will________and the total impedance will________.
   a. decrease, increase
   b. increase, decrease
   c. decrease, decrease
   d. increase, increase

18. See Figure 13-1. If the output were across the resistor, the circuit would be known as a
   a. low-pass filter.
   b. high-pass filter.
   c. band-pass filter.
   d. band-reject filter.

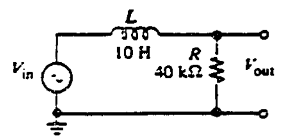


FIGURE 13-3

19. See Figure 13-3. Find the cutoff frequency.
   a. 2.5 MHz
   b. 637 Hz
   c. 1.2 MHz
   d. 408 Hz

20. See Figure 13-3. If the input voltage were 21 V, find the output voltage at the cutoff frequency.
   a. 0 V
   b. 6.15 V
   c. 14.85 V
   d. 21 V

CHAPTER 14 QUIZ

Student Name ____

1. The total reactance of a series RLC circuit at resonance is zero.
   a. true
   b. false

2. At resonance, a series RLC circuit is capacitive.
   a. true
   b. false

3. If an RLC circuit is resonant, usually $X_L = X_C$.
   a. true
   b. false

4. The bandwidth of a resonant circuit varies directly with Q: As Q increases, the bandwidth increases.
   a. true
   b. false

5. A parallel resonant circuit has maximum impedance and minimum line current.
   a. true
   b. false

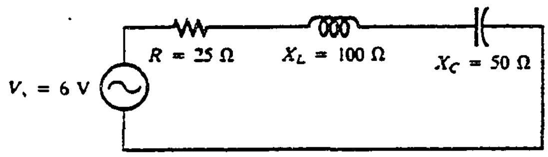


FIGURE 14-1

6. See Figure 14-1. Find the impedance of this circuit.
   a. 50 Ω
   b. 75 Ω
   c. 56 Ω
   d. 25 Ω

7. See Figure 14-1. If the frequency of the source voltage is decreased a little, the impedance will ________ and the phase angle will ________.
   a. increase, increase
   b. decrease, decrease
   c. increase, decrease
   d. decrease, increase

8. See Figure 14-1. Find the current.
   a. 107 mA
   b. 240 mA
   c. 120 mA
   d. 60 mA

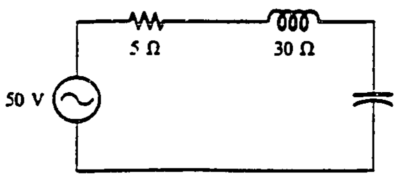


FIGURE 14-2

9. See Figure 14-2. At resonance the current will be
   a. 10 A
   b. 10 mA
   c. 1.66 A
   d. 1.66 mA

10. See Figure 14-2. The voltage across the resistor at resonance is
    a. 49.8 V
    b. 49.8 mV
    c. 50 mV
    d. 50 V

11. See Figure 14-2. At resonance, the voltage across the capacitor is
    a. 300 mV
    b. 300 V
    c. 30 V
    d. 3 V

12. In a resonant parallel RLC circuit, the impedance is________ and the total current is __________.
    a. maximum, maximum
    b. minimum, minimum
    c. maximum, minimum
    d. minimum, maximum

13. A resonant circuit with a high Q means that it
    a. has a narrow pass band.
    b. tunes broadly.
    c. has a small voltage across the capacitor.
    d. has a wide pass band.

14. The resonant frequency of a tank circuit with $L = 150\ \mu H$ and with $C = 300\ pF$ is
   a. 1.65 MHz
   b. 751 kHz
   c. 347 kHz
   d. 6.05 MHz

15. What is the bandwidth of a circuit resonant at 500 kHz, if $X_c = 2.5\ k\Omega$ and the coil resistance is 25 Ω?
   a. 100 Hz
   b. 1000 Hz
   c. 2.5 kHz
   d. 5 kHz

16. A circuit is resonant at 1 MHz. If $Q = 50$, then f_1 = ________ and f_2 = ________.
   a. 0.98 MHz, 1.01 MHz
   b. 0.99 MHz, 1.02 MHz
   c. 0.99 MHz, 1.01 MHz
   d. 0.98 MHZ, 1.02 MHz

17. The impedance of a parallel resonant circuit is 50 kΩ. The impedance of the circuit at the lower cutoff frequency is
   a. 385 kΩ
   b. 35.35 kΩ
   c. 35.35 kHz
   d. Unable to be computed, since there is not enough data.

18. The input voltage to a series resonant circuit is 120 mV. The output voltage across the inductor is 12.7 V. What is the voltage ratio of V_o to V_{in} expressed in decibels?
   a. 105.8 dB
   b. 20.2 dB
   c. 40.4 dB
   d. -19.5 dB

19. A resonant circuit is delivering 50 W of power. The power at the upper cutoff frequency is
   a. 25 W
   b. 35.35 W
   c. 50 W
   d. 70.7 W

20. A parallel resonant circuit has an X_c of 502 Ω. The source voltage is 25 V at a frequency of 14.9 MHz and $Q = 55$. What is the tank current?
   a. 270 mA
   b. 49.8 mA
   c. 9.12 mA
   d. 20.08 mA

CHAPTER 15 QUIZ

Student Name ______________________________

1. In an RC integrating circuit, the output is taken across the resistor.
   a. true
   b. false

2. In an integrator, when the pulse width of the input is much greater than 5τ, the output approaches the shape of the input.
   a. true
   b. false

3. In an RL integrating circuit, the output is taken across the resistor.
   a. true
   b. false

4. It takes a capacitor one time constant to completely charge.
   a. true
   b. false

5. An RC differentiating circuit has the output taken from across the capacitor.
   a. true
   b. false

6. An integrating circuit has R = 4.7 kΩ in series with C = 0.005 μF. What is the time constant?
   a. 23.5 μs
   b. 2.35 ms
   c. 0.0235 ms
   d. 0.00235 ms

7. An integrating circuit has R = 100 kΩ and C = 22 μF. What is the time constant?
   a. 2.2 ms
   b. 2.2 μs
   c. 2.2 s
   d. 22 s

8. A 5.1-MΩ resistor is in series with a 100-pF capacitor. How long will it take to completely charge the capacitor?
   a. 25.5 s
   b. 2.55 s
   c. 255 ms
   d. 2.55 ms

9. A 100-μF capacitor is charged to 75 V. You discharge it through a 47-kΩ resistor. How long will it take to completely discharge?
   a. 4.7 s
   b. 23.5 s
   c. 47.6 s
   d. 75 s

10. A 12-V pulse is applied to an RC integrator. The pulse width equals one time constant. What will the voltage across the capacitor be at the end of the pulse?
   a. 4.41 V
   b. 12 V
   c. 7.58 V
   d. 0 V

11. An RC integrator circuit has a C = 0.05 μF and R = 22 kΩ. A single pulse of 12 V is applied to the circuit. The pulse width is 2.2 ms. Determine the capacitor voltage at the end of the pulse.
   a. 10.38 V
   b. 12 V
   c. 7.58 V
   d. 4.42 V

12. An RC integrator has C = 47 μF and R = 12 kΩ. A square wave input with a frequency of 200 kHz is applied. The approximate output of the circuit is
   a. a square wave with a frequency of 100 kHz.
   b. 0 V.
   c. a square wave with a frequency of 200 kHz.
   d. a near dc voltage of about half the peak square wave voltage.

13. An RC differentiator circuit has C = 47 μF and R = 12 kΩ. The input signal is a square wave with a very short pulse width compared to the time constant. The output signal will be
   a. a dc value of about half the peak input voltage.
   b. a square wave very similar to the input voltage.
   c. a dc voltage level equal to the peak input voltage.
   d. zero volts.

14. An RL integrator has the output taken ________ the _______.
   a. across, resistor
   b. across, inductor
   c. across, resistor and inductor
   d. in parallel with, inductor

15. You want to fully charge a 200-μF capacitor in 12 s. What size resistor should you use?
    a. 60 kΩ
    b. 12 kΩ
    c. 6 kΩ
    d. 1.2 kΩ

16. A 47-μF capacitor is in series with a 12-kΩ resistor. A pulse of 12 V is applied for 2.256 s. What is the voltage across the capacitor?
    a. 7.58 V
    b. 10.38 V
    c. 11.4 V
    d. 12 V

17. An RL integrator circuit has L = 10 mH and R = 10 Ω. A pulse with a peak voltage of 16 V is applied for 1 ms. What is the output voltage?
    a. 10.11 V
    b. 13.84 V
    c. 15.2 V
    d. 16.32 V

18. An RL integrator has R = 25 Ω and L = 200 μH. A pulse with a peak voltage of 25 V is applied for 16 μs. What is the output voltage?
    a. 15.63 V
    b. 21.63 V
    c. 23.75 V
    d. 25 V

19. You decide to compare an RC integrator to an RL integrator. You put the same square wave signal into both circuits. The results
    a. indicate opposite action.
    b. indicate a higher voltage out from the RC integrator.
    c. indicate a higher voltage out from the RL integrator.
    d. indicate the exact same output from both circuits.

20. An RC integrator circuit can be used for
    a. obtaining good dc output.
    b. wave-shaping input waveforms.
    c. timing circuits with pulse inputs.
    d. all of the above.

APPENDIX F: POSTTEST (MIDTERM EXAMINATION)

10/8/92 & 10/9/92
Saeid Moslehpour
IEDT 140 Basic Electronics

MIDTERM

Name ______________________________

Read each question carefully before you answer. Work at a steady pace, and you should have ample time to finish. Make sure your name is on your paper before you turn it in.

1. 0.0047 amps can be expressed in metric units as 47 μA.
   a. True b. False

2. The symbol μ is an abbreviation for 10^{-6} or micro.
   a. True b. False

3. 0.00015 volts can be expressed in powers of ten as $1.5\text{x}10^{-4}$.
   a. True b. False

4. Express $5.6\text{x}10^{-2}$ in milli, basic units, and micro.

a. 5.6 milli	0.056	56000
b. 56 milli	0.056	56000
c. 560 milli	5.6 00	5600
d. 5600 milli	56	560

5. You have just calculated an answer for a problem. Your calculator reads 3.5-06. The correct metric value is
   a. 35 milli
   b. 35 micro
   c. 3.5 Meg
   d. 3.5 micro
   e. 3.5 pico

6. A device that stores energy electromagnetically is
   a. a capacitor
   b. an inductor
   c. a transistor
   d. a diode

7. An electronic device that stores electric charge is
   a. a transformer
   b. a capacitor
   c. a resistor
   d. an inductor
   e. a semiconductor

8. An electronic device that resists the flow of current in a circuit is known as
   a. a capacitor
   b. an inductor
   c. a resistor
   d. a transformer

9. A typical semiconductor device is
   a. the transformer.
   b. the diode.
   c. the resistor.
   d. the capacitor.

10. An electrical symbol for voltage is
    a. I
    b. V
    c. C
    d. R

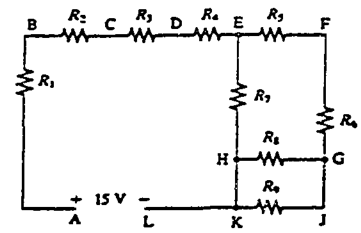
11. A normally open push button switch could have current through it when not being pushed.
    a. True b. False

MIDTERM Page 2

12. A resistor color coded with bands of yellow, violet, and orange has a value of 4.7 kΩ.
    a. True   b. False

13. A SPST switch is used to control one circuit.
    a. True   b. False

Please refer to Figure 2-2 below:



14. See figure 2-2. To measure the current that flows through R6, the circuit must be opened and the ammeter placed at point
    a. E   c. G
    b. F   d. H

15. See figure 2-2. The measured voltage V_{JK} is the same as
    a. V_{R5} c. V_{R7}
    b. V_{R6} d. V_{R8}

16. See figure 2-2. The measured voltage V_{FG} is the same as
    a. V_{R6} c. V_{R8}
    b. V_{R7} d. V_{R9}

17. See figure 2-2. Voltmeter leads placed across points C and D will read
    a. V_{R1} c. V_{R3}
    b. V_{R2} d. V_{R4}

18. See figure 2-2. The measured voltage V_{CE} is the same as
    a. V_{R5} c. $V_{R4} + V_{R5}$
    b. $V_{R3} + V_{R4}$ d. V_{R6}

19. An analog meter has
    a. a digital readout.
    b. a needle and a scale to indicate the value.
    c. no moving parts.

20. An analog ohmeter should
    a. be connected across a circuit with the power on.
    b. be inserted into the circuit so the current flows through it.
    c. placed across the resistance after the resistance is opened.
    d. have the polarity carefully checked before its use.

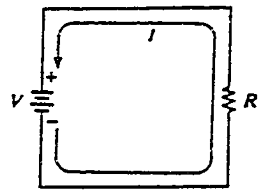
21. A circuit has a supply voltage of 15 V. The resistance is 4700 Ω. The current is 313 mA.
    a. True   b. False

MIDTERM Page 3

22. A 1 kΩ resistor has 32 mA flowing through it. The resistor is dissipating 1.024 W.
    a. True   b. False

23. A 47 kΩ resistor has 5 mA flowing through it. It is OK to use a resistor with a power rating of 1 W.
    a. True   b. False

Please refer to Figure 3-1 below:



24. See figure 3-1. If V = 50 V, and R = 25 kΩ, the current equals
    a. 50 mA   c. 0.5 mA
    b. 5 mA   d. 2 mA

25. See figure 3-1. If I = 64 mA, and R = 47 Ω, the voltage equals
    a. 30.08 V   c. 73.43 V
    b. 3.008 V   d. 7.343 V

26. See figure 3-1. If V = 85 V, and I = 15 mA, the resistance equals
    a. 1.275 Ω   c. 5.667 kΩ
    b. 52.3 Ω   d. 566 Ω

27. See figure 3-1. If V = 50 V, and I = 37 mA, the power dissipated by the resistor is
    a. 1.85 W   c. 0.185 mW
    b. 1.35 W   d. 135 mW

28. A 150 W lightbulb has a resistance measurement of 75 Ω when out of the circuit. What is the resistance of the bulb when it is energized and in a circuit with a supply of 125 V?
    a. 75 Ω   c. 9375 Ω
    b. 104 Ω   d. 2.14 Ω

29. Which is the correct formula for finding power?
    a. $P = VI$ c. $P = V^2/R$
    b. $P = I^2R$ d. all of these

30. A resistor color coded red, red, brown, and silver is connected to a 15 V source. If the resistor is within tolerance, what is the maximum current that will flow?
    a. 75.8 mA   c. 64.9 mA
    b. 62 mA   d. 71.9 mA

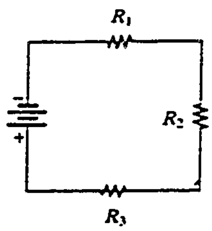
31. Three resistors, 4.7 kΩ, 2.2 kΩ, and 1.2 kΩ are in series. The total resistance is 8.7 kΩ.
    a. True   b. False

MIDTERM Page 4

32. A resistor is rated at 1/2 W. This resistor can safely dissipate 0.325 W.
a. True b. False

33. The total power dissipated in a series circuit is equal to the source voltage multiplied by the current.
a. True b. False

Please refer to Figure 4-1 below:



34. See figure 4-1. R_1 = 4.7 kΩ, V_{R1} = 10 V, R_2 = 4.7 kΩ, and R_3 = 4.7 kΩ. Calculate the voltage drops across R_2 and R_3.
a. V_{R2} = 10 V V_{R3} = 10 V
b. V_{R2} = 4.7 V V_{R3} = 10 V
c. V_{R2} = 10 V V_{R3} = 4.7 V
d. V_{R2} = 14.7 V V_{R3} = 14.7 V

35. See figure 4-1. R_1 = 4.7 kΩ, V_{R1} = 10 V, R_2 = 4.7 kΩ, and R_3 = 4.7 kΩ. Calculate the circuit current.
a. 1 mA c. 4.26 mA
b. 2.13 mA d. 6 mA

36. See figure 4-1. R_1 = 4.7 kΩ, V_{R1} = 10 V, R_2 = 4.7 kΩ, and R_3 = 4.7 kΩ. Calculate the source voltage.
a. 4.7 V c. 14.7 V
b. 10 V d. 30 V

37. See figure 4-1. If R_2 shorts, the total power dissipated in the circuit will
a. increase.
b. decrease.
c. remain the same.
d. be dependent upon the source voltage.

38. See figure 4-1. R_1 = 4.7 kΩ, V_{R1} = 10 V, R_2 = 4.7 kΩ, and R_3 = 4.7 kΩ. The total circuit resistance if R_2 shorts is
a. 0 Ω c. 9.4 kΩ
b. 4.7 kΩ d. infinite Ω

39. Two power supplies are in series with voltages of 18 V and - 6 V respectively. What is the total supply voltage?
a. -12 V c. 18 V
b. 6 V d. 12 V

MIDTERM Page 5

40. Two sources, −12 V and −6 V are connected so the total voltage is −18 V. These sources are said to be
   a. series aiding.
   b. series opposing.
   c. in parallel.
   d. dangerous to connect.

41. Three equal resistors are connected in parallel. The source voltage is 12 V. The voltage across each resistor is 4 V.
   a. True   b. False

42. A parallel branch has 0.065 mA flowing and the other branch has 0.098 mA flowing. The total current is 0.163 mA.
   a. True   b. False

43. Two resistors are in parallel. One is dissipating 0.25 W and the other is dissipating 1.2 W. The total power dissipated is 1.25 W.
   a. True   b. False

44. Three resistors are connected in parallel. The values are 2.2 kΩ, 10 kΩ, and 1.2 kΩ. What is R_T?
   a. 721 Ω
   b. 13.4 kΩ
   c. 2.27 kΩ
   d. 1.2 kΩ

45. Three resistors, 470 Ω, 680 Ω, and 830 Ω are connected in parallel. That is R_T?
   a. 1980 Ω
   b. 1510 Ω
   c. 1150 Ω
   d. 208 Ω

46. Two resistors are in parallel, 4.7 kΩ and 2.2 kΩ. The total resistance of the circuit is
   a. 2200 Ω
   b. 4700 Ω
   c. greater than 2200 Ω
   d. less than 2200 Ω

47. A parallel circuit consists of R_1 = 1.2 MΩ, R_2 = 1 MΩ, and R_3. If R_T = 0.5 MΩ, find R_3.
   a. 6 MΩ
   b. 1.7 MΩ
   c. 2 MΩ
   d. 7.7 MΩ

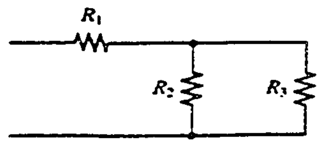
48. Three resistors are connected in parallel across a source of 15 V. The values are 5.2 MΩ, 1.2 MΩ, and 1 MΩ. If the 1.2 MΩ resistor opens, the total current will be
   a. 2.88 μA
   b. 17.88 μA
   c. 12.5 μA
   d. 2.41 μA

49. Eight 47 kΩ resistors are connected in parallel across 25 V. What is R_T?
   a. 376 kΩ
   b. 6.71 kΩ
   c. 5.875 kΩ
   d. 4.7 kΩ

50. A circuit with three resistors in parallel has a total current of 1.2 mA. If I_1 = 0.2 mA, and I_2 = 0.7 mA, find I_3.
   a. 2.4 mA
   b. 0.3 mA
   c. 7.2 mA
   d. 8.7 mA

MIDTERM Page 6

Please refer to Figure 6.1 below:



51. See figure 6-1. R_2 is in parallel with R_3.

    a. True   b. False

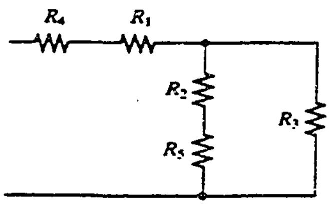
52. See figure 6-1. R_1 is in series with R_3.

    a. True   b. False

53. See figure 6-1. R_1 is in series with the parallel combination R_2 and R_3.

    a. True   b. False

Please refer to Figure 6-2 below:

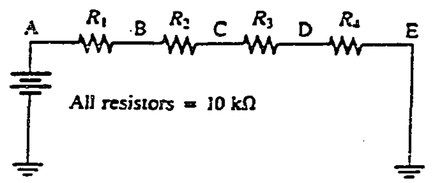


54. See figure 6-2. If all of the resistors have a value of 2.2 kΩ, find R_T.
    a. 5.87 kΩ   c. 4.4 kΩ
    b. 5.5 kΩ   d. 2.2 kΩ

55. See figure 6-2. If all of the resistors equal 2.2 kΩ and the source voltage is 15 V, find I_{R2}.
    a. 2.55 mA   c. 0.85 mA
    b. 5.11 mA   d. 0.42 mA

56. See figure 6-2. R_1, R_2, and R_3 equal 4.7 kΩ. R_4 and R_5 equal 10 kΩ. Find R_T.
    a. 6.1 kΩ   c. 24.7 kΩ
    b. 18.3 kΩ   d. 34.1 kΩ

Please refer to Figure 6-3 below:



57. See figure 6-3. The resistance between points A and D is
    a. 10 kΩ   c. 30 kΩ
    b. 20 kΩ   d. 40 kΩ

58. See figure 6-3. If V_{R1} = 15 V, find V_{BD}.
    a. 60 V   c. 30 V
    b. 45 V   d. 15 V

59. See figure 6-3. If the source voltage equals 50 V, find V_{CA}.
    a. 5 V   c. -5 V
    b. 25 V   d. -25 V

60. See figure 6-3. If the source voltage is 40 V and R_3 opens, find V_{R3}.
    a. 0 V   d. 30 V
    b. 10 V   e. 40 V
    c. 20 V

61. See figure 6-3. If another 10 kΩ resistor were placed in series with R_1, the voltage across R_4 would
    a. increase   c. remain the same
    b. decrease   d. increase to 10 V

62. See figure 6-3. The current is measured at 12 mA. Find V_{EB}.
    a. 120 V   c. -240 V
    b. -360 V   d. 240 V

63. See figure 6-3. The measured current is 1.2 mA. Find the power dissipated in the circuit.
    a. 0.576 mW   c. 57.6 mW
    b. 5.76 mW   d. 576 mW

64. See figure 6-3. V_{R3} = 17 V, find P_1.
    a. 1.7 mW   c. 2.89 W
    b. 28.9 mW   d. 17 mW

65. See figure 6-2. If R_2 shorts, V_{R3} will
    a. increase
    b. decrease
    c. remain the same

MIDTERM Page 8

66. See figure 6-1. If R_1 = 10 kΩ, R_2 = 15 kΩ, and R_3 = 50 kΩ, find R_T.
    a. 21.5 kΩ
    b. 11.5 kΩ
    c. 10 kΩ
    d. 9.5 kΩ

67. Soft iron has a high
    a. mmf
    b. permeability
    c. resistance
    d. reactance

68. Magnetic lines that are close to each other are said to have a high
    a. reluctance.
    b. inductance.
    c. flux density.
    d. current.

69. The permeability of air is said to be
    a. 1
    b. 7
    c. 19.2
    d. 22

70. A solenoid consists of
    a. two plates separated by an insulator.
    b. a burglar alarm.
    c. a coil of wire wound around a core.
    d. a permanent magnet.

APPENDIX G: FINAL EXAMINATION

May 12, 1992
Saeid Moslehpour
Basic Electronics IEDT140

Final Examination

Name ______________________________

Read each question carefully before you answer. Work at a steady pace, and you should have ample time to finish. Make sure your name is on your paper before you turn it in.

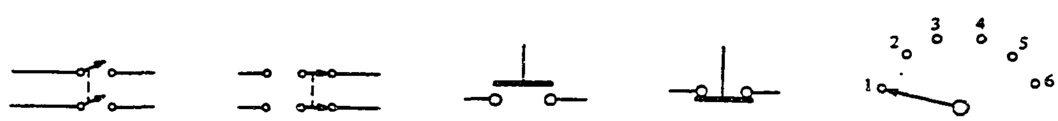
1. An electronic device that stores electric charge is
   a. a transformer
   b. a capacitor
   c. a resistor
   d. an inductor
   e. a semiconductor

2. You have just calculated an answer for a problem. Your calculator reads 3.5-06. The correct metric value is
   a. 35 milli
   b. 35 micro
   c. 3.5 Meg
   d. 3.5 micro
   e. 3.5 pico

3. Express 5.6×10^{-2} in milli, basic units, and micro.

a.	5.6 milli	0.056	56000
b.	56 milli	0.056	56000
c.	560 milli	5.6 00	5600
d.	5600 milli	56	560

Please refer to Figure 2-1 below:



(a) (b) (c) (d) (e)

4. See figure 2-1. Identify the dpdt switch.
   a. A
   b. B
   c. C
   d. D
   e. E

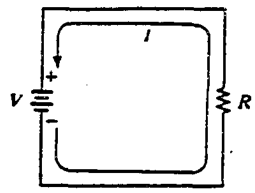
5. See figure 2-1. Which switch could be used to control a light and a fan at the same time?
   a. A
   b. B
   c. C
   d. D
   e. E

6. See figure 2-1. Which switch could be used to switch two inputs to to different output positions?
   a. A
   b. B
   c. C
   d. D
   e. E

Final Examination Page 2

7. See figure 2-1. Which switch could be used to open a circuit momentarily?
   a. A
   b. B
   c. C
   d. D
   e. E

Please refer to Figure 3-1 below:



8. See figure 3-1. If V = 60 V and R = 47 kΩ , then the current equals
   a. 1.27 mA
   b. 12.7 mA
   c. 127 mA
   d. .127 mA

9. See figure 3-1. If a resistor with a power rating of 1/2 W is used in this circuit, the current must be
   a. over 12 mA.
   b. less than 12 mA.
   c. dependent upon the voltage applied.
   d. dependent upon the voltage and the value of the resistor in the circuit.

10. See figure 3-1. If the voltage were suddenly switched on,
   a. the current would gradually decrease.
   b. the current would be zero.
   c. the current would flow.
   d. the current would gradually decrease and then increase.

11. See figure 3-1. If I = 27 mA, and R = 4.7 Ω, the voltage would equal
   a. 127 mV
   b. 5.74 V
   c. 174 mV
   d. 7.8 V

12. Two resistors are in series. R_1 = 10 kΩ and R_2 = 5 kΩ. A source voltage of 12 V is applied. V_{R1} will be ________, and V_{R2} will be ________.
   a. 8 V, 4 V
   b. 4 V, 8 V
   c. 8 V, 8 V
   d. 4 V, 4 V

13. A series circuit with four resistors connected across a 30 V source has a current of 0.125 mA flowing through it. Three of the resistors have values of 10 kΩ, 33 kΩ, and 47 kΩ. What is the value of the fourth resistor?
   a. 150 Ω
   b. 1.5 kΩ
   c. 15 kΩ
   d. 150 kΩ

Final Examination Page 3

14. The polarity of voltages across a resistor is dependent on the current direction. The resistor end where current leaves is said to be ___________, and the other end is __________.
    a. positive, positive
    b. negative, negative
    c. negative, positive
    d. positive, negative

15. A 50 kΩ potentiometer is connected across 15 V. The voltage from the wiper to the lower end of the pot is 3.2 V. What is the resistance of the lower part of the potentiometer?
    a. 10.67 kΩ
    b. 39.3 kΩ
    c. 50 kΩ
    d. 0 Ω

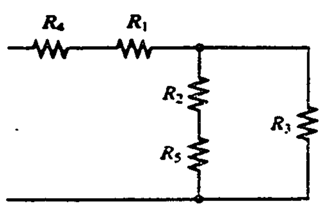
16. The power dissipated in any branch of a parallel circuit is
    a. dependent on the power rating of the resistor.
    b. only dependent on the circuit voltage.
    c. only dependent on the total current.
    d. dependent on the voltage and value of the resistor.

17. You have a four-resistor parallel circuit. If you want to measure the current through one of the parallel resistors with a DVM, the meter is connected
    a. in series with the resistor.
    b. across the source.
    c. in parallel with the resistor.
    d. in series with the source.

18. A parallel circuit consists of $R_1 = 10$ kΩ and R_2. The value of R_T is 6.8 kΩ. Find R_2.
    a. 16.8 kΩ
    b. 3.2 kΩ
    c. 21.25 kΩ
    d. 12 kΩ

19. As resistors are removed from a parallel circuit,
    a. I_T decreases and R_T increases.
    b. I_T decreases and R_T decreases.
    c. I_T increases and R_T decreases.
    d. I_T increases and R_T increases.

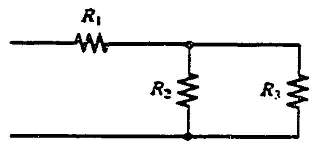
Please refer to Figure 6-2 below:



20. See figure 6-2. If R_2 shorts, V_{R3} will
    a. increase
    b. decrease
    c. remain the same

Final Examination Page 4

Please refer to Figure 6.1 below:



21. See figure 6-1. If R_1 = 10 kΩ, R_2 = 15 kΩ, and R_3 = 50 kΩ, find R_T.
    a. 21.5 kΩ
    b. 11.5 kΩ
    c. 10 kΩ
    d. 9.5 kΩ

22. See figure 6-1. If R_1 = 10 kΩ, R_2 = 15 kΩ, and R_3 = 50 kΩ, and the source voltage equals 25 V, calculate the total current.
    a. 2.17 mA
    b. 2.5 mA
    c. 1.58 mA
    d. 1.16 mA

23. If a combination of four parallel 10 kΩ resistors were in series with a single 20 kΩ resistor, and one of the parallel combination resistors shorted, the voltage across the other parallel resistors would
    a. increase.
    b. decrease.
    c. remain the same.

24. A simple electric door bell probably uses __________ to ring the bell.
    a. a vacuum tube
    b. a relay
    c. an electromagnet
    d. a permanent magnet

25. A relay is a device that
    a. uses an electromagnet to open and close contacts.
    b. can be very small or very large.
    c. that has a coil to actuate some contacts to control other circuits.
    d. all of the above

26. Commercial line voltages are usually square waves at a frequency of 60 Hz.
    a. True b. False

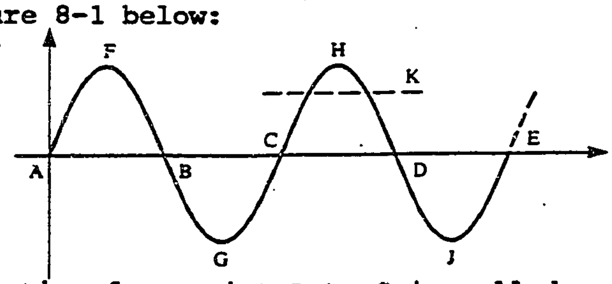
27. If an ac voltage is applied to a resistor the current will increase.
    a. True b. False

28. A formula for V_{rms} is
    a. $0.707V_{rms}$
    b. $0.707V_p$
    c. $2V_p$
    d. $2.8V_p$

Final Examination Page 5

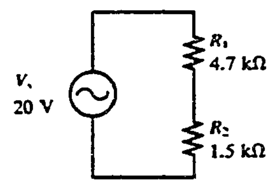
29. A sine wave has a peak value of 169 V. What is the instantaneous value at a angle of 17° from the start of a cycle?
a. 49.4 V
b. 98.8 V
c. 161 V
d. 80.5 V

Please refer to Figure 8-1 below:



30. See figure 8-1. The time from point A to C is called
a. the frequency.
b. V_p.
c. the period.
d. the rms voltage.

Please refer to Figure 8-2 below:



31. See figure 8-2. Find R_T.
a. 1.13 kΩ
b. 4.7 kΩ
c. 4.77 kΩ
d. 6.2 kΩ

32. See figure 8-2. Solve for V_{R1p-p}.
a. 21.44 V
b. 6.84 V
c. 42.88 V
d. 13.68 V

33. See figure 8-2. If R_2 shorts, V_{R2} will
a. increase.
b. decrease.
c. remain the same.
d. not change since the source is ac.

34. See figure 8-2. Find the instantaneous voltage of R_1 at an angle of 122°.
a. 18.18 V
b. 5.8 V
c. 11.15 V
d. 11.6 V

35. The vertical deflection of a scope trace is 1.6 cm. The volts/division switch is set on 50 mV/cm. The voltage is
a. 80 mV
b. 50 mV
c. 1.6 mV
d. 0.008 V

Final Examination Page 6

36. If the area of the plates of a capacitor is decreased, then the capacitance will decrease.
    a. True b. False

37. The time constant is the time required for a capacitor to fully charge.
    a. True b. False

38. A capacitor has a charge of 1.175 μC and a voltage of 25 V across it. What is the capacitance?
    a. 0.047 μF
    b. 0.47 μF
    c. 4.7 μF
    d. 47 μF

39. A 0.47 μF capacitor has a voltage across it of 18 V. What charge is stored in the capacitor?
    a. 846 μF
    b. 84.6 μF
    c. 8.46 μF
    d. 0.846 μF

40. A capacitor is to be used in a circuit where the ac voltage is 120 V. What should the dc working voltage of the capacitor be?
    a. 120 V
    b. 169 V
    c. 84.8 V
    d. 339 V

41. Three capacitors are in series. C_1 = 0.047 μF, C_2 = 0.047 μF, C_3 = 0.47 μF, and the source voltage is 25 V. What is C_T and the voltage across C_2.
    a. 0.022 μF and 11.9 V
    b. 0.022 μF and 25 V
    c. 0.564 μF and 1.2 V
    d. 0.564 μF and 11.9 V

42. Two capacitors are connected in parallel across a 15 V source. C_1 = 22 μF and C_2 = 100 μF. Find C_T and the voltage across C_1.
    a. 18 μF and 15 V
    b. 18 μF and 5.2 V
    c. 122 μF and 15 V
    d. 1220 μF and 30 V

43. A 47 μF capacitor is in series with a 120 kΩ resistor. What is the time constant?
    a. 0.564 ms
    b. 564 ms
    c. 5.64 s
    d. 54.6 s

44. A 22 μF capacitor is in series with a 47 kΩ resistor. How long will it take for the capacitor to completely charge?
    a. 1.034 s
    b. 2.068 s
    c. 8.272 s
    d. 5.17 s

45. A 22 μF capacitor is in series with a 4.7 kΩ resistor. How long will it take for the capacitor to completely discharge through the resistor?
    a. 0.827 s
    b. 0.517 s
    c. 0.207 s
    d. 0.103 s

46. If an inductor is placed in a circuit with ac applied, the voltage across the inductor leads the current through it.
    a. True b. False

Final Examination Page 7

47. When a dc voltage is first applied to an inductor, the circuit current is zero.
    a. True   b. False

48. Two identical inductors A and B have different currents through them. Inductor A's current is the larger. Which inductor has the greatest inductance?
    a. A
    b. B
    c. both have the same

49. Three inductors are in series. L_1 = 14 mH, L_2 = 22 mH, and L_3 = 45 mH. Determine the total inductance.
    a. 81 µH   c. 81 mH
    b. 7.2 mH   d. 20 mH

50. A 50 mH inductor is in series with a 50 kΩ resistor. The source voltage is 50 V. What is the maximum current that will flow in the circuit?
    a. 1 µA   c. 1 mA
    b. 100 µA   d. 10 mA

51. A 25 mH inductor has a voltage of 50 V with a frequency of 400 Hz applied to it. Find X_L.
    a. 62.8 Ω   c. 6.28 kΩ
    b. 628 Ω   d. 62.8 kΩ

52. A 15 µH inductor is applied in a circuit. The X_L of the inductor is 2.2 kΩ. Determine the operating frequency.
    a. 23.4 kHz   c. 4.28 MHz
    b. 23.4 MHz   d. 4.28 kHz

53. An inductor has a dc voltage applied to it. How many time constants will it take to completely build the magnetic field around it?
    a. 1   d. 4
    b. 2   e. 5
    c. 3

54. A 100 µH inductor with a resistance of 12 Ω is supplied with a source with a frequency of 100 kHz. What is X_L?
    a. 62.8 kΩ   c. 6.28 Ω
    b. 62.8 Ω   d. infinite

55. An inductor is in a circuit with a voltage of 25 V. The current is 1.25 mA and the frequency is 100 Hz. What is X_L?
    a. 31.25 Ω   c. 3.125 kΩ
    b. 15.7 kΩ   d. 20 Ω

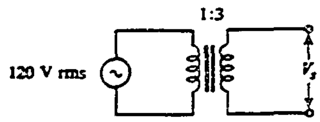
56. If a dc voltage is applied to the primary of a transformer, an ac voltage is induced in the secondary.
    a. True   b. False

57. A transformer with a turns ratio of 1:7 is a step down transformer.
    a. True   b. False

Final Examination Page 8

58. When a 12 V battery is connected across the primary of a transformer with a turns ratio of 1:4, the secondary voltage is
a. 0 V
b. 12 V
c. 48 V
d. 3 V

Please refer to Figure 11-1 below:



59. See figure 11-1. If there are five times more turns in the primary than in the secondary, what is the secondary voltage?
a. 600 V
b. 120 V
c. 24 V
d. 12 V

60. See figure 11-1. If the ratio of primary to secondary turns is changed to 9:1, what is the output voltage V_s?
a. 13.3 V
b. 26.6 V
c. 53.2 V
d. 106 V

61. See figure 11-1. If the primary to secondary turns ratio is changed to 4:1, and a load resistor of 1 kΩ is in the secondary, what is the secondary current I_s?
a. 480 mA
b. 240 mA
c. 120 mA
d. 30 mA

62. See figure 11-1. The primary to secondary turns ratio is 1:3 and I_s = 120 mA. What is the primary current I_p?
a. 360 mA
b. 40 mA
c. 180 mA
d. cannot compute because the voltage is not given

63. See figure 11-1. The primary to secondary turns ratio is changed to 2.5:1 and I_s = 100 mA. What is the reflected resistance seen by the primary?
a. 1.2 kΩ
b. 2.5 kΩ
c. 3 kΩ
d. 5 kΩ

64. A circuit is giving you problems. The power transformer is delivering zero output volts. The input voltage to the primary is correct. A probable trouble is
a. an partially shorted secondary.
b. an open primary.
c. a shorted primary.
d. a partially shorted primary.

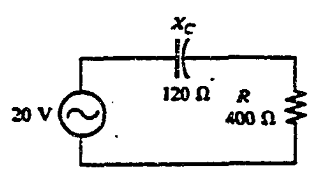
Final Examination Page 9

65. You are going to buy a matching transformer to match a 600 Ω audio load to a 4 Ω speaker system. The primary should have __________ more turns than the secondary.
a. 12.24
b. 150
c. 3.06
d. The primary should have less turns than the secondary.

66. The total current in an RC circuit always lags the source voltage.
a. True b. False

67. The phasor combination of X_C and R is called Z.
a. True b. False

Please refer to Figure 12-1 below:



68. See figure 12-1. If the frequency is 400 Hz, what is the value of capacitance?
a. 3.3 μF
b. 6.6 μF
c. 8.8 μF
d. 10 μF

69. See figure 12-1. If the source voltage is changed to 100 V, find the impedance.
a. 120 Ω
b. 280 Ω
c. 418 Ω
d. 520 Ω

70. See figure 12-1. If the source voltage is changed to 100 V, calculate the true power.
a. 22.9 W
b. 22.9 mW
c. 3.66 W
d. 11 W

71. See figure 12-1. If the operating frequency is decreased, what effect will that decrease have on the current? It will
a. increase.
b. remain the same.
c. decrease.
d. decrease to zero.

72. See figure 12-1. If the operating frequency is decreased, what effect will that decrease have upon the phase angle? It will
a. increase.
b. remain the same.
c. decrease.
d. change to another quadrant.

73. See figure 12-1. If the operating frequency is decreased, what effect will that decrease have upon the value of the capacitor? It will
a. increase.
b. remain the same.
c. decrease.
d. change to another quadrant.

Final Examination Page 10

74. See figure 12-1. If the operating frequency is decreased, what effect will it have on the value of the resistor? It will
a. increase.
c. decrease.
b. remain the same.
d. open.

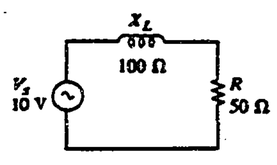
75. See figure 12-1. If the resistor is changed to 2.2 kΩ, what effect will that change have upon the total current? It will
a. increase.
c. decrease.
b. remain the same.
d. decrease to zero.

76. The impedance of an RL series circuit varies inversely with the frequency.
a. True b. False

77. The impedance of a series RL circuit is found by adding the values of X_L and R.
a. True b. False

78. The cutoff frequency of a high-pass RL filter is 55 kHz. The filter's bandwidth is
a. 55 kHz
c. 0 kHz
b. 110 kHz
d. unknown

Please refer to Figure 13-1 below:



79. See figure 13-1. If the frequency is changed to 400 Hz, what is the value of the inductance?
a. 39.8 mH
c. 25.12 mH
b. 39.8 H
d. 25.12 H

80. See figure 13-1. If the source voltage is changed to 100 V, find the impedance.
a. 104 Ω
c. 1.12 kΩ
b. 112 Ω
d. 1.04 kΩ

81. See figure 13-1. If the source voltage were changed to 100 V, calculate the true power.
a. 40 mW
c. 16 W
b. 4 W
d. 40 W

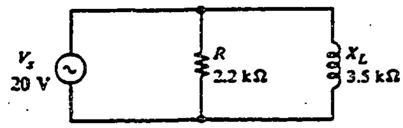
82. See figure 13-1. If the operating frequency is decreased, the current will
a. increase
c. remain the same
b. decrease
d. decrease to zero

Final Examination Page 11

83. See figure 13-1. If the operating frequency is decreased, the phase angle will
a. increase.
b. decrease
c. remain the same.
d. change to another quadrant.

84. See figure 13-1. If the operating frequency is decreased, the value of inductance will
a. increase.
b. decrease
c. remain the same.
d. decrease to zero.

Please refer to Figure 13-2 below:

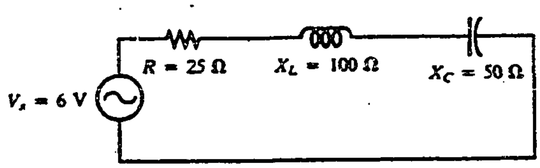


85. See figure 13-2. If the value of the resistor is changed to 1.5 kΩ, the total current will
a. increase.
b. decrease.
c. remain the same.
d. decrease to zero.

86. At resonance, a series RLC circuit has an impedance equal to the resistance.
a. True b. False

87. A parallel resonant circuit has minimum impedance and maximum line current.
a. True b. False

Please refer to Figure 14-1 below:



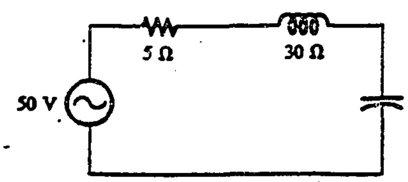
88. See figure 14-1. If you desired to operate this circuit at a frequency above resonance, you would __________ the resistance and __________ the frequency.
a. increase, increase
b. decrease, decrease
c. not change, increase
d. not change, decrease

89. See figure 14-1. If the frequency of the source voltage is decreased, the impedance will __________ and the current will __________.
a. decrease, decrease
b. decrease, increase
c. increase, increase
d. increase, decrease

Final Examination Page 12

90. See figure 14-1. If the resistance R were decreased, the impedance would
    a. increase
    b. decrease
    c. remain the same
    d. become zero

Please refer to Figure 14-2 below:



91. See figure 14-2. If the value of R were decreased, the bandwidth would
    a. increase.
    b. remain the same.
    c. decrease.
    d. vary.

92. See figure 14-2. If the resistor shorts, the current would
    a. increase.
    b. not change.
    c. decrease.
    d. continue but the circuit would not be resonant.

93. A resonant circuit with a high Q means that it
    a. has a very wide pass-band.
    b. tunes sharply.
    c. has no pass-band.
    d. has a small voltage across the capacitor.

94. The resonant frequency of a tank circuit with L = 150 mH and C = 300 pF is
    a. 23.7 Hz
    b. 23.7 kHz
    c. 237 kHz
    d. 2.37 MHz

95. What is the bandwidth of a circuit resonant at 1.42 MHz, if X_C = 3.5 kΩ and the coil resistance is 8 ohm?
    a. 3.245 kHz
    b. 2285 Hz
    c. 1.42 MHz
    d. 32.5 kHz

96. An RC integrating circuit has a 22 kΩ resistor in series with a 0.02 μF capacitor. What is the time constant?
    a. 0.044 ms
    b. 0.044 μs
    c. 0.44 ms
    d. 0.44 s

97. An integrating circuit has a 10 kΩ resistor in series with a 220 μF capacitor. What is the time constant?
    a. 2.2 ms
    b. 22 ms
    c. 0.22 ms
    d. 2.2 s

98. A 5.2 MΩ resistor is in series with a 0.22 μF capacitor. How long will it take to completely charge the capacitor? The source voltage is 12 V.
    a. 5.72 s
    b. 1.144 s
    c. 2.288 s
    d. 4.576 s

99. A 0.47 μF capacitor is charged to 15 V. You discharge it through a 10 kΩ resistor. How long will it take to completely discharge the capacitor?
    a. 2.35 s
    b. 0.47 ms
    c. 23.5 ms
    d. 0.18 ms

100. A 30 V pulse is applied to an RC integrator. The pulse width equals one time constant. Find V_C at the end of the pulse.
    a. 18.96 V
    b. 25.95 V
    c. 28.5 V
    d. 29.4 V